5.3 Water Quality

This section discusses short-term impacts on water quality from operations and construction of Hanford solid waste (HSW) disposal sites and related facilities and potential long-term impacts on groundwater and the Columbia River from contaminant releases from HSW disposal facilities after site closure in 2046 based on conservative assumptions used in this EIS. Short-term potential impacts during the period of operations and construction are discussed in Section 5.3.1. An overview of assessment methods used to determine the long-term impacts to groundwater and the Columbia River are presented in Section 5.3.2. Detailed information on the long-term assessment methods and results are provided in Appendix G. Section 5.3.3 discusses the use of immobilized low-activity waste (ILAW) performance assessment (PA) calculations to support this EIS. Details from the water quality analysis presented in Section 5.3.4 and in Appendix G are used in the preparation of estimates of impacts on public health and safety, as provided in Section 5.11.

As a result of wastewater management activities during past Hanford Site operations, groundwater beneath the 200 Areas has been contaminated with radionuclides and non-radioactive chemicals. The contaminants emanating from the 200 Areas are moving toward the Columbia River. Radioactive contaminants present in groundwater beneath the 200 Areas that exceed values cited in Table 4.10, Maximum Concentrations of Groundwater Contaminants at Hanford in FY 2001 (Section 4.5.2), are tritium, strontium-90, technetium-99, iodine-129, plutonium, cesium-137, total alpha, total beta, and uranium. Hazardous chemical contaminants present at levels exceeding values in Table 4.9 include nitrate, fluoride, chromium, carbon tetrachloride, trichloroethene, cyanide, tetrachloroethene, and cis-1, 2-dichloroethene. None of these contaminants are thought to have originated from the LLBGs being considered in this EIS (Hartman et al. 2002).

5.3.1 Short-Term Impacts of Operations and Construction Activities

Water derived from the Hanford Site Export Water System is used for dust suppression during operations and construction. The Hanford Site Export Water System extracts potable water for fire suppression and industrial use from the Columbia River for use in the Central Plateau from intake locations in the 100 D Area. Water from the export system is also expected to be used at existing sanitary facilities and would be disposed of after treatment. Because most of these operational water discharges would occur in uncontaminated areas, the discharges would not be expected to have a substantial effect on the groundwater system from leaching or the driving force of the wastes. Groundwater quality impacts would not be expected. In the case of capping the HSW disposal facilities at closure where water is used for short-term dust suppression, the 25-cm (10-in) layer of asphalt at the base of the cap is expected to divert water away from the waste and is not expected to result in impacts to groundwater quality.

Solid LLW disposed of after 1988 in the HSW disposal facilities is largely dry solid waste with limited amounts of free liquid that could otherwise result in waste leaching and release through the vadose zone and into the groundwater. Since that time, LLW has been categorized into Category (Cat) 1 and Cat 3 LLW based on stringent waste acceptance criteria for radionuclide inventory content. Following these waste acceptance criteria, systematic use of waste containment and containers such as emplacing all wastes in steel boxes, drums, high-integrity containers (HIC), and grouted waste forms has also been

implemented beginning in 1995 to minimize leaching and release of contaminants during the period of operations. In addition, MLLW is being disposed of in RCRA-compliant trenches with a liner system to facilitate monitoring, management, and treatment of leachate during operations (see Section 3.1).

Because waste containment using containers described above was not systemically used prior to 1995, contaminants contained in solid LLW disposed of in LLBGs prior to 1995 offer the highest potential for leaching and release into the vadose zone prior to site closure. The analysis conducted for the HSW EIS conservatively evaluated the potential impacts of these earlier disposals by evaluating the effect of higher infiltration rates during operations. Results of analyses of earlier disposal facilities used release and vadose zone infiltration rates of 5 cm/yr, a rate reflective of managed bare surface soil conditions over the older disposal areas during the operations phase. Mobile contaminants (such as technetium-99 and iodine-129) disposed of before 1995 were estimated to arrive several hundred years before mobile contaminants disposed of after 1995. Peak concentrations of technetium-99 and iodine-129 were estimated to arrive at down-gradient locations between years 2050 and 2100 from 200 East Area locations and year 2150 and 2200 from 200 West Area locations. Descriptions of the underlying assumptions and resulting estimated impacts (that is, contaminant concentration levels and peak arrival times) from these analyses are provided in detail in Appendix G.

5.3.2 Methods for Assessment of Long-Term Impacts

The groundwater exposure pathway considers the long-term release of contaminants from a variety of LLW and MLLW downward through the vadose zone underlying the HSW disposal facilities, and laterally through the unconfined aquifer immediately underlying the vadose zone to the Columbia River. The LLBG areas are all located in the 200 Areas, and the physical area of potential groundwater impact is the unconfined aquifer bounded laterally by the Rattlesnake Hills to the west and southwest, by the Columbia River to the north and east, and by the Yakima River to the south (see Section 4.1, Figure 4.1).

The sequence of calculations used in the long-term assessment required using a suite of process models that estimated source-term release, vadose zone flow and transport, and groundwater flow and transport. The computational framework for these process models and relationship of software elements is schematically illustrated in Figure 5.1.

Wastes considered in this assessment include previously disposed of wastes and wastes to be disposed of in the HSW disposal facilities (for purposes of analysis, year 2007 was assumed to be the date when new disposal facilities would be operational):

- Previously disposed of LLW, which includes:
- LLW disposed of in LLBGs between 1962 and 1970 (referred to as pre-1970 LLW in this section)
- LLW disposed of in LLBGs after 1970, but before October 1987 (referred to as 1970-1987 LLW in this section)

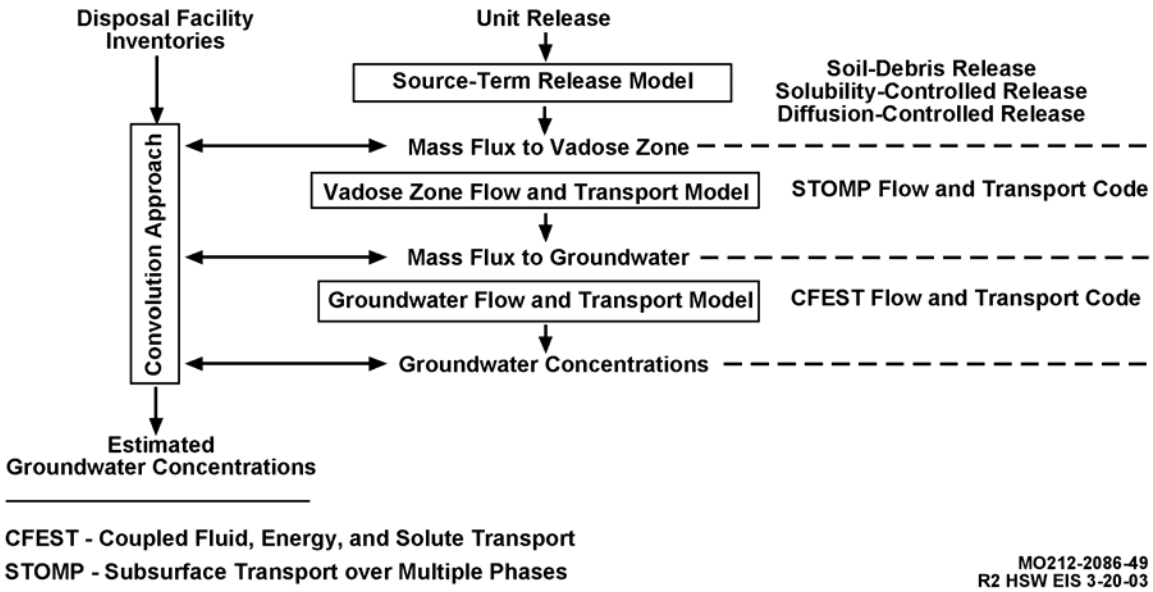

Figure 5.1. Schematic Representation of Computational Framework and Codes Used in the HSW EIS

- LLW disposed of in LLBGs after October 1987, but before 1995 (referred to as 1988-1995 LLW in this section)

- Cat 1 LLW, which includes:

- Cat 1 LLW disposed of in the LLBGs after 1995 including Cat 1 LLW forecasted to be disposed of through 2007 (referred to as Cat 1 LLW [1996-2007] in this section)

- Cat 1 LLW disposed of after 2007 including Cat 1 LLW forecasted to be disposed of through 2046 (referred to as Cat 1 LLW disposed of after 2007 in this section). For purposes of analysis, year 2007 was assumed to be the date when new disposal facilities would be operational

- Cat 3 LLW, which includes:

- Cat 3 and greater than Cat 3 (GTC3) LLW disposed of in the LLBGs after 1995 including Cat 3 LLW forecasted to be disposed of through 2007 (referred to as Cat 3 LLW [1996-2007] in this section)

- Cat 3 and GTC3 LLW disposed of after 2007 including Cat 3 LLW forecasted to be disposed of through 2046 (referred to as Cat 3 LLW disposed of after 2007 in this section).

- MLLW, which includes:

- MLLW disposed of after 1996 including MLLW forecasted to be disposed of through 2007 (referred to as MLLW [1996-2007] in this section).

- MLLW disposed of after 2007 including MLLW forecasted to be disposed of through 2046 (referred to as MLLW disposed of after 2007 in this section).

- Melters from the tank waste treatment program

- ILAW from the tank waste treatment program.

Inventories of retrievably stored transuranic (TRU) waste in trenches and caissons located in the LLBGs were not evaluated for their groundwater impacts because the TRU waste will be retrieved and sent to the Waste Isolation Pilot Plant for disposal.

Although not specifically required by current regulations for LLW management, this assessment examined water quality impacts for up to 10,000 years after the operational period Current requirements under the guidelines for performance assessment of LLW disposal facilities, as prescribed in (DOE 2001b), focus on impacts during the first 1,000 years after disposal.

This groundwater assessment was performed using a combination of screening techniques and numerical modeling. The groundwater modeling results estimate contaminant concentrations in the groundwater associated with selected alternatives evaluated in this HSW EIS from the end of waste operations in 2046 up to 10,000 years from 2046. This analysis also evaluates potential early waste release and contaminant transport from previously disposed wastes including pre-1970 LLW, 1970-1987 LLW, and 1988-1995 LLW and examines the potential for release and vadose zone transport during the operational period.

The lines of analysis (LOAs) used in this comparative assessment were located on the Hanford Site along lines approximately 1 km (0.6 mi) down-gradient from the 200 East and West Areas and ERDF, and near the Columbia River, as shown in Figure 5.2[(a)]. All locations were selected based on simulated transport results of unit releases at selected HSW disposal facilities. These LOAs in each area are not meant to represent points of compliance, but rather common locations to facilitate a comparison of the waste management activities and locations defined for each alternative group. Constituent concentrations presented for each alternative group from specific water category releases represent maximum concentrations estimated along these LOAs. Because of the variation in the location of the different waste types and category releases for a given alternative group, the estimated maximum concentrations calculated from a specific waste category release may not correspond to the same point on the line analysis for every waste category and alternative group. Combined concentration levels presented for each LOA and alternative group reflect the summation of estimated concentration levels regardless of their position on the LOA.

(a) It may be noted in Figure 5.2 that the HSW disposal facilities are not contiguous units and therefore a 100-m assessment that may be appropriate on a trench-by-trench basis would not lend itself to a comparison of the alternatives presented in this EIS. That analysis would be prepared as part of the performance assessment process, as described in Section 5.18.4. (More detailed illustrations of the location of the LLBGs are provided in Section 4.0, Figures 4.4 and 4.5.)

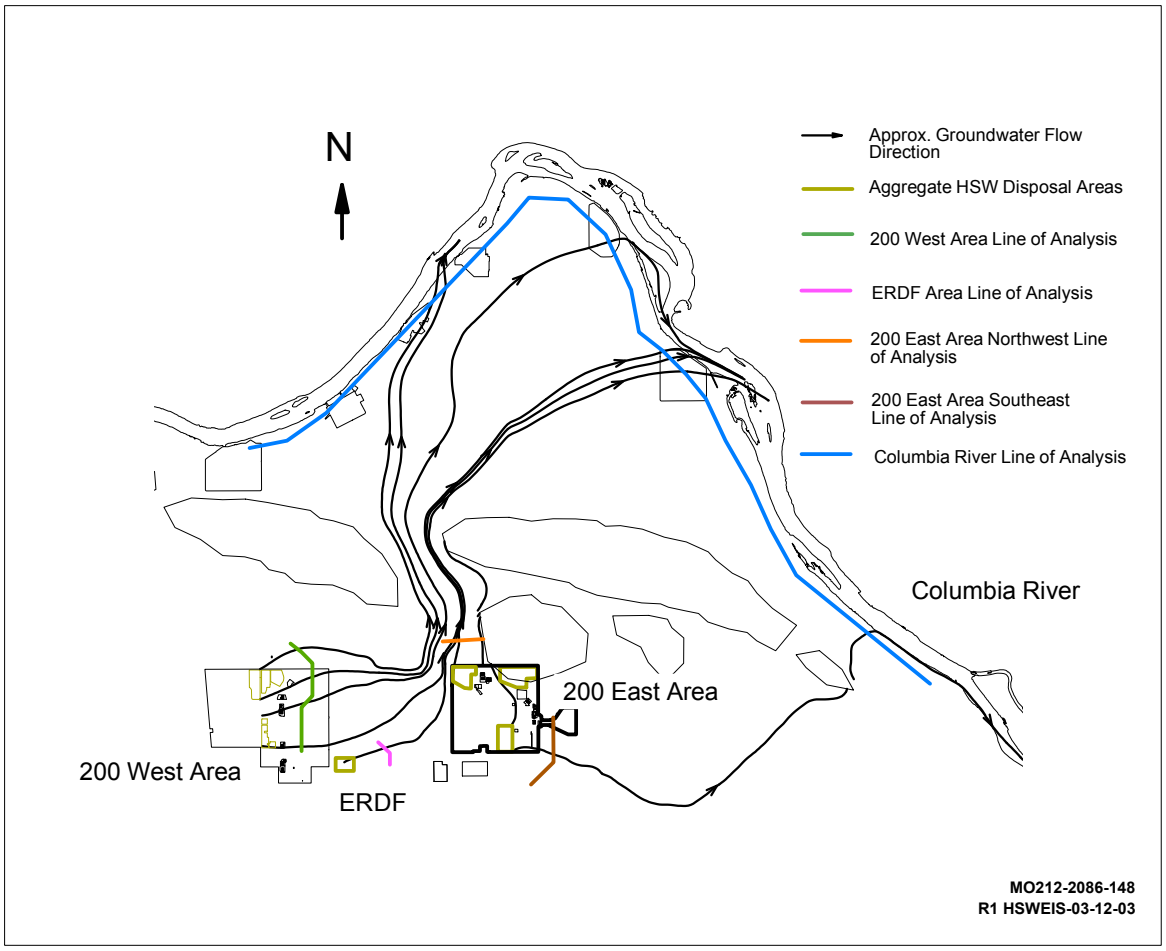

Figure 5.2. LOAs Used in Assessing Long-Term Water Quality Impacts

Delineation of waste impacts in the 200 East Area required two different LOAs. One LOA, designated as the 200 East Northwest (NW) LOA, is used to evaluate concentrations in groundwater migrating northwest of the 200 East Area. Another LOA, designated as the 200 East Southeast (SE) LOA, is used to evaluate concentrations in groundwater migrating southeast of the 200 East Area.

The HSW disposal facilities contain over 100 radioactive and non-radioactive waste constituents. Potential impacts to groundwater within the 10,000-year period of analysis were based primarily on the overall mobility of the constituents. To establish their relative mobility, the constituents were grouped based on their mobility in the vadose zone and underlying unconfined aquifer. Contaminant mobility classes were used rather than the individual mobility of each contaminant because of the uncertainty involved in determining the mobility of individual constituents. The mobility classes were selected based on relatively narrow ranges of mobility. Some of the constituents, such as iodine and technetium, would move at the same rate as water whether they were in the vadose zone or underlying groundwater. The movement of other constituents in water, such as americium, cesium, plutonium, and strontium, would be retarded by interaction with soil and rock.

The constituents considered in this assessment have a broad range of mobility when their affinity to being sorbed during transport in the vadose zone and groundwater environment is considered. The flow and transport models used in this analysis account for these differences in mobility by the use of a factor commonly referred to as the retardation factor (Rf). This factor, which relates the velocity of the contaminant to the velocity of pore water, is typically calculated using a distribution coefficient, or K_d, which has units of mL/g. This parameter is a measure of sorption and is the ratio of the quantity of the solute adsorbed per gram of solid to the amount of solute remaining in solution (Kaplan et al. 1995). Values of K_d for the constituents range from 0 mL/g (in which the contaminant movement in water is not retarded) to more than 40 mL/g (in which the contaminant moves at a much slower rate than water).

The constituents in the LLW inventory were grouped and modeled according to the reported or assumed K_d of each constituent. The constituent mobility classes, based on mobility and examples of common or potential constituents of concern, are described in the following text. A complete list of solid LLW constituents by K_d is provided in Appendix G. The constituent mobility classes used for modeling include:

- **Mobility Class 1** – Contaminants were modeled as non-sorbing (that is, $K_d = 0$) and would not be retarded in the soil-water system. Contaminant K_d values in this group ranged from 0 to 0.59 mL/g and include all the isotopes of iodine, technetium, selenium, chlorine, and tritium.

- **Mobility Class 2** – Contaminants were modeled as slightly sorbing (that is, $K_d = 0.6$) and would be slightly retarded in the soil-water system. Contaminant K_d values in this group ranged from 0.6 to 0.99 mL/g and include all the isotopes of uranium and carbon.

- **Mobility Class 3** – Contaminants were modeled as slightly more sorbing (that is, $K_d = 1$). Contaminant K_d values in this group ranged from 1 to 9.9 mL/g and include all the isotopes of barium.

- **Mobility Class 4** – Contaminants were modeled as moderately sorbing (that is, $K_d = 10$). Contaminant K_d values in this group ranged from 10 to 39.9 mL/g and include all the isotopes of neptunium, palladium, protactinium, radium, and strontium.

- **Mobility Class 5** – Contaminants were modeled as strongly sorbing (that is, $K_d = 40$). Contaminant K_d values in this group were 40 mL/g or greater and include all the isotopes of actinium, americium, cobalt, curium, cesium, iron, europium, gallium, niobium, nickel, lead, plutonium, samarium, tin, thorium, and zirconium.

Estimated inventories of hazardous chemical constituents associated with LLW and MLLW disposed of after 1988 being considered under each alternative group would be expected to be found at trace levels. MLLW, which would be expected to contain the majority of hazardous chemical constituents, would undergo predisposal solidification to stabilized-waste forms and containment and thermal treatment to remove organic chemical components of the MLLW. This waste treatment would be done to meet current waste acceptance criteria and land disposal restrictions before being disposed of in permitted

MLLW facilities. Consequently, groundwater quality impacts from these constituents would not be expected to be substantial.

Analysis of MLLW inventories for this assessment did identify two exceptions that included lead and mercury inventories associated with the projected MLLW that were estimated at 336 kg (741 lb) and 2.5 kg (5.5 lb), respectively. Because of its affinity to be sorbed into Hanford sediments, lead falls within Mobility Class 5 (K_d = 40 mL/g) and would not release to groundwater within the 10,000-year period of interest. The inventory estimated for mercury is assumed to be small enough that it would not release to groundwater in substantial concentrations. Even the most conservative estimates of release would yield estimated groundwater concentrations at levels of two orders of magnitude below the current standard of 0.002 mg/L.

LLW disposed of prior to September 1987 may contain hazardous chemical constituents, but no specific requirements existed to account for or report the content of hazardous chemical constituents in this category of LLW. As a consequence, analysis of these constituents and estimated impacts based on the limited amount of information on estimated inventories and waste disposal locations would be subject to uncertainty at this time. (Additional discussion on uncertainties is presented in Section 3.5.) These facilities are part of the LLW and MLLW facilities in the LLW Management Areas 1 – 4 that are currently being monitored under RCRA interim status programs. Final closure of these facilities under RCRA and/or CERCLA guidelines will eventually require analysis of the impacts of the chemical components of these inventories. Any analysis with information that is currently available would be at best speculative without more detailed inventory characterization information. Such analyses would require a more thorough and detailed characterization of these wastes at some future date.

The source term is the quantification of when and which constituents (by mass or activity) would be released. This source term includes the water flux into the vadose zone that results from precipitation infiltrating the waste and mass or activity solubilized from dissolution of waste in the HSW disposal facilities. A detailed description of the source term and the rates of release of constituents into the groundwater are contained in Appendix G. Methods used for calculating source release and transport of constituents in the vadose zone and groundwater are also described in Appendix G.

5.3.2.1 Previously Disposed of Waste and Category 1 Low-Level Waste

Previously disposed of LLW and Cat 1 LLW were evaluated using similar modeling approaches. Previously disposed of LLW consists of waste emplaced in the HSW disposal facilities from 1962 to 1970 and between 1970 and 1987; Cat 1 LLW consists of waste emplaced since 1988 and forecasted to be emplaced in the future in the 200 East Area and the 200 West Area.

Assumptions for analysis of these LLW types include:

- All LLW would be buried by 2046. At the beginning of the analysis period, all constituents of concern are assumed to be available for transport via infiltrating precipitation to the vadose zone and for eventual arrival at the groundwater.

- The start of release is variable and dependent on the waste category. Because of uncertainties in the use of waste containers and containment prior to 1995, releases for the pre-1970 LLW, 1970-1987 LLW, and 1988-1995 LLW were conservatively approximated by initiating waste releases in 1966, 1976, and 1996, respectively. Since 1995, the use of more robust waste containment and waste forms (that is, the use of steel drums and steel boxes for Cat 1 LLW and the use of macroencapsulated grouting and HICs for Cat 3 LLW) has become a standard practice. Thus the start of release of all LLW and MLLW disposed of after 1995 was assumed to be delayed at least until the time of site closure in 2046.

- Source-term release for the LLW was estimated using the soil-debris release model. In this model, the waste itself is assumed to have the same hydraulic characteristics of the surrounding soil materials. The inventory in the LLW is conservatively assumed to be immediately available for leaching and would be leached out of the HSW disposal facilities at the assumed infiltration rate.

- For all alternatives involving previously disposed of LLW before 1996, the soil-debris release model assumed an infiltration rate of 5 cm/yr during the period of operations before year 2046. This assumption of infiltration provides conservative estimates of waste release to groundwater for earlier disposals (prior to 1995) when waste containment was not as robust. This assumed release model infiltration rate was used for the pre-1970 LLW, the 1970-1988 LLW, and the 1988-1995 LLW.

- For all alternatives involving wastes disposed of after 1995, the soil-debris release model assumed sufficient waste containment to delay release until after site closure.

- For Alternative Groups A through E, all waste disposal sites are assumed to be covered with a modified RCRA Subtitle C cover system. To approximate the effect of the cover on waste release, the following assumed infiltration rates were used in the waste release modeling. For 500 years after site closure, an infiltration rate of 0.01 cm/yr was used to approximate the effect of cover emplacement over the wastes and its impact on reducing infiltration. After 500 years, the cover is assumed to begin to degrade. Between 500 and 1000 years after site closure, infiltration rates were increased linearly from 0.01 cm/yr to 0.5 cm/yr to approximate a 500-year period of cover degradation and a return infiltration rate reflective of natural vegetated surface soil conditions over the wastes. The final rate of 0.5 cm/yr was used for the remaining 9,000-year period of analysis. For the No Action Alternative, the release modeling from these wastes used an infiltration rate of 0.5 cm/yr, which is assumed to be an appropriate infiltration rate for naturally vegetated surface soil conditions that would persist under this alternative after site closure.

- A specific case of leaching was used to estimate the release of uranium from the LLW. For uranium, the release was controlled at a solubility limit of 64 mg/L, a conservative estimate of uranium solubility at Hanford estimated by Wood et al. (1995) for LLW in the 200 West Area.

- During the post-closure period (that is, after 2046), the infiltration rate used for vadose zone flow was assumed to be 0.5 cm/yr to reflect natural recharge in the surrounding environment of naturally vegetated surface soil conditions. In the absence of artificial recharge, vadose simulation results

based on this assumed infiltration rate indicated a travel time to the water table of about 560 years in the 200 East Area and 900 years in the 200 West Area.

- Thickness of the LLW was assumed to be 6 m (20 ft) for disposal in the existing trenches and 15.6 m (51 ft) for the enhanced design waste trenches (deeper, wider trenches in Alternative Group A; single expandable trenches in Alternative Group C; and in the lined modular facility in Alternative Groups D_1, D_2, D_3, E_1, E_2, and E_3).

- A number of the alternatives considered, specifically, the use of liner systems to control waste release during the period of operations. However, no specific credit for the effect of these liner systems was considered in this long-term analysis. Although the liner systems, as described in Section 3.1, might last (contain leachate for removal) for several hundred years if properly managed, this analysis assumed that the emplaced liners would fail during the 100-year active institutional control period and would have little effect on the long-term waste release during the 10,000-year period of analysis.

5.3.2.2 Cat 3 Low-Level Waste

Assumptions for analysis of Cat 3 LLW that differ from those of Cat 1 LLW follow:

- Because all Cat 3 LLW is either buried in high-integrity containers (HICs) constructed of concrete or disposed of by in-trench grouting, the calculations assumed a delay in contaminant release (the design lifetime of an individual HIC). Source-term releases of carbon-14 and iodine-129 were estimated using the soil-debris release model with the assumed delay in release to account for containment of the LLW in either HIC or in-trench grouting. In this model, the inventory in the LLW was conservatively assumed to be immediately available for leaching. The exception to this approach was technetium-99 and uranium in LLW. The technetium-99 LLW was assumed to be disposed of within the HIC in a macroencapsulated grout form, and the release of technetium-99 was assumed to be controlled by diffusion through the grout.

- The leaching of uranium disposed of in cementitious waste forms (that is, in macroencapsulated grout or HICs) was based on a solubility-controlled release model that used an assumed lower uranium solubility limit of 0.2 mg/L (Wood et al 1996). This solubility limit, which is lower than the 64 mg/L used for leaching of uranium in non-cemented wastes, is a conservative representation of uranium solubility in the alkaline geochemical conditions created by the presence of cement in the disposal environment. Additional information on recent studies of leaching of uranium from cementitious waste forms is available in (Krupka and Serne 1996; Serne et al. 1996).

5.3.2.3 Mixed Low-Level Waste

MLLW analyzed in this section include wastes emplaced since 1988 and waste forecasted to be emplaced in the future. Trenches 31 and 34 in LLBG 218-W-5 in the 200 West Area have been constructed specifically for disposal of MLLW. MLLW in excess of the capacity of these trenches is assumed to be disposed of in newly constructed MLLW trenches in designated locations defined in Alternative Groups A through E.

Assumptions for analysis of MLLW that differ from those of Cat 1 LLW follow:

- Some of the MLLW would be disposed of in a matrix of macroencapsulated grout similar to Cat 3 LLW.

- The thickness of the MLLW disposed of in the 200 West Area in Trenches 31 and 34 within LLBG 218-W-5 is 6 m (20 ft). Depth of the MLLW disposed of in the 200 East Area in the enhanced trench at other LLBG locations was assumed to be 15.6 m (51 ft).

5.3.2.4 Melters from the Waste Treatment Program

Melters analyzed in this section are forecasted to be emplaced in a new 21-m (69-ft) deep disposal trench, which would be constructed in locations designated in Alternative Groups A through E.

Assumptions for analysis of melters that differ from those of MLLW follow:

- The depth of the melter trench, wherever constructed, would be 21 m (69 ft), and the waste thickness would be 18.6 m (61 ft).

- The melters were assumed to be macroencapsulated in grout. Thus, the release of inventories of constituents contained within this waste was assumed to be controlled by the presence of grout. The release of technetium-99 was assumed to be controlled by diffusion using the diffusion-controlled release model. The release of uranium isotopes was assumed to be controlled by a solubility-controlled release models using a solubility limit of 0.2 mg/L. (This value is used for uranium release from other waste categories that use cementitious waste forms.) All of these waste release assumptions would represent a conservative treatment of waste release for these melters since constituents contained within these wastes would be contained in thick heavy gauge steel and encapsulated and incorporated in a vitrified waste mass and would likely be controlled by a much lower release rate related to steel corrosion and glass degradation.

5.3.3 Use of ILAW Performance Assessment Calculations to Support the HSW EIS

Impact results presented for the ILAW disposal in this assessment were not based on independent calculations used in the previously described methodology, but rather relied on recent performance assessment calculations made for siting the ILAW Hanford solid waste (HSW) in the vicinity of the PUREX Plant, as summarized in Mann et al. (2001).

Under a number of alternatives (Alternative Groups A, C, D_1, and E_3) where ILAW disposal is sited near the PUREX facility, results of a sensitivity case in Mann et al. (2001) that analyzed the effect of 25,550 Ci of technetium was used. This case reflected no technetium removal in the separation processes from the Waste Treatment Plant. This technetium-99 inventory (25,550 Ci) is a factor of 4.4 higher than the estimated inventory of technetium-99 (about 5,790 Ci) if technetium-99 removal were considered in the separation process.

In this analysis, the results for the ILAW case cited above were superimposed directly onto the results of other waste categories calculated for this analysis at the operational area (the 200 East and 200 West Areas and ERDF) and Columbia River LOAs, as appropriate for each alternative. When ILAW is disposed of near the PUREX Plant (Alternative Groups A, C, and E_3), these results were superimposed with other waste category impacts at the 200 East Area SE LOA. When ILAW is disposed of in the 200 East Area LLBGs (Alternative Group D_1), these results were superimposed with other waste category impacts at the 200 East Area SE LOA.

For other alternative groups, the ILAW disposal is sited in areas south of the CWC (Alternative Group B) and at ERDF (Alternative Groups A, C, D_1, and E_3) and the calculated impacts at these alternative sites would be expected to be different because of the changes in hydrogeologic conditions and hydraulic properties at these three locations. Results of this scaling suggest that predicted groundwater concentrations would be a factor of about 3 higher and about 3.4 higher at the 1-km LOA down-gradient of the HSW disposal site (south of CWC and at ERDF) locations, respectively, relative to a comparable location down-gradient from the PUREX location. Peak concentrations estimated along the Columbia River from these alternative locations of disposal would be about 20 and 10 percent lower, respectively, than was calculated from releases near the PUREX location. The reductions in concentrations levels would be consistent with the longer flow path to the Columbia River.

The methods used to adapt the performance assessment results to the analysis in the HSW EIS are provided in Appendix G, Section G.3.

5.3.4 Long-Term Impacts on Water Quality

Of the suite of LLW constituents disposed of in the HSW disposal facilities, only technetium-99 and iodine-129 in Mobility Class 1 and carbon-14 and the uranium isotopes in Mobility Class 2 were considered to be in sufficient quantity, long-lived, and mobile enough to warrant detailed analysis of groundwater impacts. Although three of the constituents in Mobility Class 1—selenium, chlorine, and tritium—are considered to be very mobile, they were excluded from analysis because the total inventories for selenium and chlorine were considered negligible (less then 1×10^{-2} Ci) and tritium, because of its relatively short half-life, would reach groundwater from the HSW disposal facilities in very small quantities.

Estimates of transport times of constituents in Mobility Classes 3, 4, and 5 indicated their release through the thick vadose zone to the unconfined aquifer beneath the HSW disposal facilities would be beyond the 10,000-year period of analysis. Thus all constituents in these mobility classes were eliminated from further analysis.

Federal drinking water standards are used as benchmarks against which potential contamination levels may be compared. For the contaminants of interest, the Federal drinking water standards (40 CFR 141.16) are based on EPA's calculated dose equivalent of 4 mrem/yr to the maximally exposed internal organ or total body. Effective December 8, 2003, uranium will have a standard of 0.03 mg/L, based on chemical toxicity that is more restrictive than the radiological dose standard (65 FR 76708).

Drinking water standards for Washington State are stated in WAC 246-290. Federal standards are given in 40 CFR 141 and 40 CFR 143.

Concentrations of key constituents (primarily technetium-99 and iodine-129) for all HSW types disposed of in the 200 Areas, at ERDF, and near the PUREX Plant for the LOAs by alternative group over 10,000 years for the Hanford Only and Upper Bound waste volumes are provided in Figures 5.3 to 5.21. These results represent the incremental impacts from wastes considered in this EIS (cumulative impacts of these wastes combined with other Hanford sources are presented in Section 5.14). For reference, maximum concentration limits for technetium-99 and iodine-129 are 900 and 1 pCi/L, respectively. Human health impacts are presented in Section 5.11.

Summary level discussions of impacts on water quality for each alternative group are presented in the following sections. These discussions primarily focus on quantitative estimates of potential impacts related to releases of technetium-99 and iodine-129. Qualitative discussion of the impacts from carbon-14 and the uranium isotopes is also provided.

5.3.4.1 Alternative Group A

LLW considered in Alternative Group A includes several different waste categories for disposal:

- Pre-1970 LLW
- 1970-1987 LLW
- 1988-1995 LLW
- 1996-2007 Cat 1 and Cat 3 LLW
- Cat 1 and Cat 3 LLW and MLLW disposed of after 2007 in deeper (18 m) (59 ft) and wider trenches in existing LLBGs 218-E-12B 218-E-12B and 218-W-5
- Melters disposed of after 2007 in 21-m (69-ft) deep trenches in LLBG 218-E-12B
- ILAW disposed of after 2007 in a HSW disposal facility near the PUREX Plant.

Alternative Group A results for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.3 and 5.4. These results show the impacts to groundwater quality at various lines of analyses starting in the year 2000. The impacts shown reflect: (1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and (3) later increasing releases of technetitum-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12,046 A.D.). Additional information can be found in several tables and figures in Section G.2.1 of Appendix G.

5.3.4.1.1 Previously Disposed of Wastes

Constituents released from previously disposed of wastes in the LLBGs that have the highest impact on water quality are technetium-99 and iodine-129. Estimated combined technetium-99 and iodine-129 levels at the 200 East Area NW LOA peaked at about 110 years after assumed start of release and at about 220 years after assumed start of release at the 200 West Area LOA. Combined concentration levels of technetium-99 were relatively low (less than 20 pCi/L) at the 1-km LOAs, and reflect about 2 percent of the benchmark maximum concentration level for technetium-99 (900 pCi/L). The combined concentration level of iodine-129 at the 200 East NW LOA was about 60 percent (0.6 pCi/L) of the benchmark maximum concentration level. This concentration level resulted from releases of the iodine-129 inventory in the 1970-1987 LLW. The combined concentration level of iodine-129 at the 200 West Area LOA was about 50 percent (0.5 pCi/L) of the benchmark maximum concentration level. This concentration level also resulted from releases of the iodine-129 inventory in the 1970-1987 LLW.

Technetium-99 and iodine-129 combined concentrations were well below benchmark maximum concentration levels by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA reached their peaks in about 260 years after assumed start of release. Contaminant levels from sources in the 200 West Area reached their peaks along the river LOA between 500 and 600 years after assumed start of release.

Carbon-14 and the uranium isotopes combined concentrations were found to peak at about or beyond 10,000-year period of analysis. Carbon-14 concentrations at all 1-km LOAs were well below the benchmark maximum concentration level of 2000 pCi/L. Combined concentration levels of uranium-238, the dominant uranium isotope, also were well below the benchmark maximum concentration levels at the 200 East and West Area LOAs at 10,000 years after site closure.

5.3.4.1.2 Wastes Disposed of after 1995

Water quality impacts from wastes disposed of after 1995 were also highest for technetium-99 and iodine-129. Technetium-99 levels at the 200 East Area NW LOA were about 8 percent (75 pCi/L) of the benchmark maximum concentration level for the Hanford Only waste volume. The source for these elevated levels is from technetium-99 released from the MLLW disposed of after 2008. Technetium-99 levels at the 200 West Area LOA were about 33 percent (300 pCi/L) of the benchmark maximum concentration level. The source of these impacts was primarily from the technetium-99 releases from the Cat 3 LLW disposed of after 2008. Predicted technetium-99 releases were very similar for all volumes but were slightly higher for the Upper Bound waste volume.

Iodine-129 levels at the 200 East Area NW LOA were about 80 percent of the benchmark maximum concentration level of 1 pCi/L for the Hanford Only waste volume. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of MLLW disposed of after 2008. Iodine-129 levels at the 200 West Area LOA were about 40 percent of the benchmark maximum concentration level of 1 pCi/L for the Hanford Only waste volume. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of MLLW disposed of between 1996 and 2007.

Iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This result is reflective of changes in partitioning the iodine-129 inventory for the MLLW (1996-2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Technetium-99 and iodine-129 concentrations were well below benchmark maximum concentration levels by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks between 1550 and 1600 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks the Columbia River LOA between 1600 and 2100 years after site closure.

Concentration levels of carbon-14 and the uranium isotopes at the 1-km (0.6-mi) LOAs did not reach their peak values until after the 10,000-year period of analysis and were well below benchmark maximum concentration levels at 10,000 years after site closure.

5.3.4.2 Alternative Group B

LLW considered in Alternative Group B includes the same waste considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW and MLLW in conventional trenches after 2007 in LLBGs 218-E-12B and 218-W-5 and the ILAW disposal facility located just south of the CWC.

Alternative Group B results for combined technetium-99 and iodine-129 concentration levels for the Hanford Only and Upper Bound waste volumes are summarized in Figures 5.5 and 5.6. As in Alternative Group A, these results show the impacts to groundwater quality at various lines of analyses from: (1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and 3) later increasing releases of technetitum-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12,046 A.D.). Additional information is found in several tables and figures in Section G.2.2 of Appendix G.

5.3.4.2.1 Previously Disposed of Wastes

Impacts from previously disposed of wastes were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1).

5.3.4.2.2 Wastes Disposed of after 1995

- Under this alternative group, water quality was most impacted by releases of technetium-99 and iodine-129 from disposed LLW and MLLW. Technetium-99 levels at the 200 East Area NW LOA were about 11 and 13 percent (95 and 116 pCi/L) for the Hanford Only and Upper Bound waste volumes, respectively. The primary source for these elevated levels was from inventories in MLLW disposed of after 2008. These higher concentration levels are generally consistent with the broader surface area of releases associated with the use of conventional trenches under this alternative group.

- Technetium-99 levels at the 200 West Area LOA were estimated to be about 33 percent (300 pCi/L) of the benchmark maximum concentration level of 900 pCi/L for the Hanford Only and Upper Bound waste volumes. These values are slightly less than levels estimated for Alternative Group A. However, this would be expected since the source of these impacts was primarily from the technetium-99 inventories in the Cat 3 LLW disposed of after 2008, and the use of conventional trenches under this alternative group would result in some of the inventory associated with Cat 1 and Cat 3 LLW disposed of after 2007 being emplaced in the 200 East Area.

- Iodine-129 levels at the 200 East Area NW LOA were 90 and 120 percent (0.9 and 1.2 pCi/L) of the benchmark maximum concentration level of 1 pCi/L for the Hanford Only and Upper Bound waste volumes, respectively. The main contributor to these concentration levels was the release of iodine-129 inventories in ungrouted parts of the MLLW disposed of after 2008. Iodine-129 levels at the 200 West Area LOA were about 40 and 20 percent (0.4 and 0.2 pCi/L) of the benchmark maximum concentration level for the Hanford Only waste volume. The main contributor to these concentration levels was from iodine-129 inventories in the ungrouted part of the MLLW disposed of between 1996 and 2007.

- Iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This impact is reflective of changes in partitioning the iodine-129 inventory for the MLLW (1996-2007) waste category between the 200 East and West Areas for the Upper Bound waste volume.

Concentration levels of carbon-14 and the uranium isotopes at the 1-km (0.6-mi) LOAs down-gradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark maximum concentration levels at 10,000 years after site closure.

Concentrations of all constituents were well below benchmark maximum concentration levels by the time they reached the Columbia River LOA. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area sources reached their peaks along the river at about 1500 years after site closure.

5.3.4.3 Alternative Group C

LLW considered in Alternative Group C includes the same wastes considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW in a single, lined expandable trench and MLLW in another single, lined expandable trench after 2007 in LLBGs 218-E-12B and 218-W-5. The melters would be placed in a lined trench and ILAW would be placed in a single, expandable, lined trench near the PUREX Plant.

Alternative Group C results for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.7 and 5.8. As in Alternative Groups A and B, these results show the impacts to groundwater quality at various lines of analyses from: (1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995

that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and (3) later increasing releases of technetitum-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12,046 A.D.). Additional information is provided in several tables and figures in Section G.2.3 of Appendix G.

5.3.4.3.1 Previously Disposed of Wastes

Impacts from previously disposed of wastes were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1).

5.3.4.3.2 Wastes Disposed of after 1995

Because of assumptions in the source-term release and vadose zone modeling used for previously buried LLW and LLW and MLLW disposed of between 1996 and 2007 for Alternative Group C, results for this alternative group were the same for those waste categories calculated for Alternative Group A. Results for LLW and MLLW disposed of after 2007 for this alternative group were essentially the same as those presented in these figures for Alternative Group A. These results are consistent since the analysis assumption about waste depth and projected land use for waste disposed of after 2007 are the same for both alternative groups.

5.3.4.4 Alternative Group D_1

LLW considered in Alternative Group D_1 includes the same wastes considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW and MLLW in a lined, modular facility after 2007 near the PUREX Plant. The melters and ILAW would also be placed adjacent to this HSW disposal facility.

Alternative Group D_1 results for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.9 and 5.10. As was provided in the previous alternatives groups, these results show the impacts to groundwater quality at various lines of analyses from: (1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and (3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12,046 A.D.). Additional information can be found in several tables and figures in Section G.2.4 in Appendix G.

5.3.4.4.1 Previously Disposed of Wastes

Impacts from previously disposed of wastes were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1).

5.3.4.4.2 Wastes Disposed of after 1995

Highest impacts for this alternative group reflect the emplacement of all wastes disposed of after 2007 in the vicinity of the PUREX Plant. Impacts from LLW and MLLW are dominated by technetium-99 and iodine-129.

Combined concentration levels for technetium-99 were about 18 to 20 percent (167 and 185 pCi/L) of the benchmark maximum concentration level at the 200 East SE LOA for the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in MLLW disposed of after 2008. Two peaks reflect technetium-99 inventories in both Cat 3 LLW and MLLW disposed of after 2008 near the PUREX area.

Combined technetium-99 concentration levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes. These values are slightly less than levels estimated for Alternative Group A. The source of these impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined iodine-129 concentration levels at the 200 East SE LOA were about 60 and 70 percent (0.6 and 0.7 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes. The main contributor to these concentration levels was iodine-129 inventories in ungrouted parts of the MLLW disposed of after 2008.

Combined iodine-129 levels at the 200 West Area LOA were about 40 and 20 percent (0.4 and 0.2 pCi/L) of the benchmark maximum concentration level for the for the Hanford Only and Upper Bound waste volumes. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007. Combined iodine-129 levels were slightly higher at the 200 East Area SE LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. These results are reflective of changes in partitioning of iodine-129 inventory for the MLLW (1996-2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined concentration levels of carbon-14 and the uranium isotopes at the 200 East and West Area LOAs from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark maximum concentration levels at 10,000 years after site closure.

Technetium-99 and iodine-129 concentrations were well below benchmark maximum concentration levels by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks along the river between 1400 and 1500 years after site closure. Contaminant levels at the same LOA from sources in the 200 West Area sources reached their peaks between 2100 and 2200 years after site closure.

5.3.4.5 Alternative Group D_2

LLW considered in the Alternative Group D_2 include the same wastes considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW and MLLW in a single-lined, modular trench after 2007 in LLBG 218-E-12B. The melters and ILAW would also be placed in the same HSW disposal facility.

Alternative Group D_2 results for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.11 and 5.12. As was provided in the previous alternative groups, these results show the impacts to groundwater quality at various lines of analyses from: (1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and (3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12, 046 A.D.). Additional information can be found in several tables and figures in Section G.2.5 of Appendix G.

5.3.4.5.1 Previously Disposed of Wastes

Impacts from previously disposed of wastes were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1).

5.3.4.5.2 Wastes Disposed of after 1995

Highest impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 in the 218-E-12B LLBG. These impacts were primarily from technetium-99 and iodine-129.

- Combined technetium-99 levels at the 200 East Area NW LOA were about 16 and 19 percent (148 and 169 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in Cat 3 LLW and MLLW disposed of after 2007.

Combined concentration levels of technetium at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes, respectively. These values are slightly less than levels estimated for Alternative Group A. The source of these impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

The highest combined iodine-129 levels at the 200 East Area NW LOAs were about 86 and 95 percent (0.86 and 0.95 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes. The main contributor to these concentration levels was ungrouted iodine-129 inventories in MLLW disposed of after 2008.

The highest combined iodine-129 levels were about 40 and 20 percent (0.4 and 0.2 pCi/L) of the benchmark maximum concentration level at the 200 West Area LOA for the Hanford Only waste volume. The main contributor to these concentration levels was ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

The highest iodine-129 levels were slightly higher at the 200 East Area NW LOA and slightly lower at the 200 West Area LOA for the Upper Bound waste volume. This is reflective of changes in partitioning of the iodine-129 inventory for the MLLW (1996-2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Concentration levels of carbon-14 and the uranium isotopes at all 1-km (0.6-mi) LOAs did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark maximum concentration levels at 10,000 years after site closure.

Technetium-99 and iodine-129 concentrations were well below the benchmark maximum concentration levels by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks between 1500 and 1600 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks along the river at about 2000 years after site closure.

5.3.4.6 Alternative Group D_3

LLW considered in the Alternative Group D_3 includes the same wastes considered in Alternative Group A but disposes of Cat 1 and Cat 3 LLW and MLLW at ERDF. The melters and ILAW would also be placed at ERDF.

Alternative Group D_3 results for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volume are summarized in Figures 5.13 and 5.14. As was provided in the previous alternative groups, these results show the impacts to groundwater quality at various lines of analyses from: (1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and (3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12,046 A.D.). Additional information can be found in several tables and figures in Section G.2.6 of Appendix G.

5.3.4.6.1 Previously Disposed of Wastes

Impacts from previously disposed of wastes were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1).

5.3.4.6.2 Wastes Disposed of after 1995

The highest water quality impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 at ERDF. Impacts were primarily from technetium-99 and iodine-129.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volumes under this alternative group. Combined technetium-99 levels at the 200 East Area NW LOA were about 2 percent (15.7 pCi/L) of benchmark maximum concentration levels for the Upper Bound waste volume. The primary source for these elevated levels was from inventories in MLLW disposed of between 1996 and 2007.

Combined technetium-99 levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes. These values are slightly less than levels estimated for Alternative Group A. The source of these impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and 2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined technetium-99 levels at ERDF LOA were about 27 and 28 percent (242 and 253 pCi/L) of the benchmark maximum concentration levels for the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in the Cat 3 LLW disposed of after 2008.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volume under this alternative group. Combined iodine-129 levels at the 200 East Area NW LOA were about 95 percent (0.95 pCi/L) of the benchmark maximum concentration level for the Upper Bound waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were 40 and 20 percent (0.4 and 0.2 pCi/L) of the benchmark maximum concentration level for the Hanford Only waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were slightly higher at the 200 East Area NW LOA and slightly lower for the Upper Bound waste volume. This result reflects assumed changes in partitioning of the iodine-129 inventory for the MLLW (1996-2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined iodine-129 levels at ERDF LOA were 92 and 94 percent (0.92 and 0.94 pCi/L) of the benchmark maximum concentration level for the Hanford Only waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of after 2008.

Concentration levels of carbon-14 and the uranium isotopes at all LOAs down-gradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark maximum concentration levels at 10,000 years after site closure.

Combined technetium-99 and iodine-129 concentrations were well below benchmark maximum concentration levels by the time they reached the Columbia River. Overall concentration levels from sources in the 200 East Area reached their peaks along the river at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks along the river at about 2000 years after site closure.

5.3.4.7 Alternative Group E_1

Alternative Group E_1 results for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.15 and 5.16. As was provided in the previous alternative groups, these results show the impacts to groundwater quality at various lines of analyses from: (1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and (3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12,046 A.D.). Additional information can be found in several tables and figures in Section G.2.7 of Appendix G.

5.3.4.7.1 Previously Disposed of Wastes

Impacts from previously disposed of wastes were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1).

5.3.4.7.2 Wastes Disposed of after 1995

Impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 in 218-E-10B and the disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 are identical to results for the same wastes in Alternative D_2. The highest impacts resulted from releases of technetium-99 and iodine-129.

Combined technetium levels at the 200 East Area NW LOA were about 16 and 19 percent (148 and 169 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in Cat 3 LLW and MLLW disposed of after 2008.

Combined technetium-99 levels at the 200 West Area LOA were about 5 and 3 percent (42 and 31 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes. These values are slightly less than levels estimated for Alternative Group A. The source of these impacts was primarily from the technetium-99 inventory in MLLW disposed of between 1996 and

2007. Decreased concentrations for the Upper Bound waste volume reflect the emplacement of some of the MLLW inventory in the 200 East Area.

Combined technetium-99 levels at ERDF LOA were about 0.3 percent (2.7 pCi/L) of the benchmark maximum concentration level for both the Hanford Only and Upper Bound waste volumes. The primary source for these elevated levels was from inventories in the melters disposed of after 2008.

No LLW and MLLW were disposed of after 1996 in the 200 East Area for the Hanford Only waste volume under this alternative group. Combined iodine-129 levels at the 200 East Area NW LOA were 95 percent (0.95 pCi/L) of the benchmark maximum concentration level for the Upper Bound waste volume. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were 40 and 20 percent (0.4 and 0.2 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes. The main contributor to these concentration levels was from ungrouted iodine-129 inventories in MLLW disposed of between 1996 and 2007.

Combined iodine-129 levels at the 200 West Area LOA were slightly higher at the 200 East Area NW LOA and slightly lower for the Upper Bound waste volume, which is reflective of changes in partitioning of the iodine-129 inventory for the MLLW (1996-2007) waste category between the 200 East and West Areas for the Upper Bound inventory.

Combined iodine-129 levels were 22 percent (0.22 pCi/L) at ERDF LOA for the Hanford Only and Upper Bound waste volumes. No iodine-129 inventory was estimated for melters disposed of at ERDF after 2007 for this alternative group.

Concentration levels of carbon-14 and the uranium isotopes at the 1-km (0.6-mi) well down-gradient from source areas of projected LLW and MLLW did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below benchmark maximum concentration levels at 10,000 years after site closure.

Technetium-99 and iodine-129 concentrations were well below the benchmark maximum concentration levels by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks along the river at about 1400 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks along the river at about 2000 years after site closure.

5.3.4.8 Alternative Group E_2

Results for Alternative Group E_2 for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.17 and 5.18. As was provided in the previous alternative groups, these results show the impacts to groundwater quality at various lines of analyses from: (1) early releases of technetium-99 and iodine-129 to groundwater from

LLW disposed of prior to 1995 that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and (3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12,046 A.D.). Additional information can be found in several tables and figures in Section G.2.8 of Appendix G.

5.3.4.8.1 Previously Disposed of Wastes

Impacts from previously disposed of wastes were the same for all alternative groups. This discussion is presented under results for Alternative Group A (see Section 5.3.4.1).

5.3.4.8.2 Wastes Disposed of after 1995

Impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 near the PUREX Plant and the disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007 are identical to results for the same wastes in Alternative Group D_1 (See Section 5.3.4.4.2). Results for the melters were the same as those calculated for Alternative Group E_1 (See Section 5.3.4.7.2).

5.3.4.9 Alternative Group E_3

Alternative Group E_3 results for combined technetium-99 and iodine-129 concentration levels for Hanford Only and Upper Bound waste volumes are summarized in Figures 5.19 and 5.20. Additional information can be found in several tables and figures in Section G.2.9 Appendix G.

5.3.4.9.1 Previously Disposed of Wastes

Impacts from previously disposed wastes were the same for all alternative groups. This discussion is presented under results for Alternative Group A results in (see Section 5.3.4.1).

5.3.4.9.2 Wastes Disposed of after 1995

Impacts for this alternative group reflect emplacement of LLW and MLLW disposed of after 2007 near the PUREX Plant and the disposal of melters and ILAW at ERDF. Results for LLW and MLLW disposed of after 2007, excluding the MLLW, are identical to results for the same wastes in Alternative Group D_3 (See Section 5.3.4.6.2).

Combined technetium-99 levels were slightly less than 2.5 percent (22 pCi/L) of the benchmark maximum concentration level at the 200 East Area SE LOA for the Hanford Only waste volume. The impact for the Hanford Only waste volume reflects the impact of the melter wastes and ILAW disposals near the PUREX Plant. The highest combined iodine-129 levels at the 200 East Area SE LOA were about 0.2 percent (0.2 pCi/L) of the benchmark maximum concentration level for the Hanford Only and Upper Bound waste volumes as a result of the ILAW disposal near PUREX.

5.3.4.10 No Action Alternative

The No Action Alternative for combined technetium-99 and iodine-129 concentration levels are summarized in Figure 5.21. As was provided in the previous alternative groups, these results show the impacts to groundwater quality at various lines of analyses from: (1) early releases of technetium-99 and iodine-129 to groundwater from LLW disposed of prior to 1995 that peak in the next 100 to 200 years, (2) later releases of the same constituents from LLW and MLLW disposed of after 1996 that peak between the years 3000 and 4000, and (3) later increasing releases of technetium-99 and iodine-129 from ILAW disposal that peak at the end of the period of analysis (that is, year 12,046 A.D.). Additional information can be found in several tables and figures in Section G.2.10 of Appendix G.

5.3.4.10.1 Previously Disposed of Wastes

The highest water quality impacts from previously disposed of wastes are related to technetium-99 and iodine-129 releases. Estimated concentrations of technetium-99 and iodine-129 peaked at about 110 years after assumed start of release at the 200 East Area NW LOA and about 220 years after assumed start of release at the 200 West Area LOA. Combined levels of technetium-99 were less than 2 percent (18 pCi/L) at the 200 East NW and West Area LOAs. Combined levels of iodine-129 at 200 East Area NW LOA were less than 0.1 percent (0.09 pCi/L) of the benchmark maximum concentration level.

Combined levels of iodine-129 at 200 West Area LOA were about 50 percent (0.5 pCi/L) of the benchmark maximum concentration level. This concentration level resulted from releases of the iodine-129 inventory in 1970-1987 LLW.

Carbon-14 and the uranium isotopes concentration were found to peak at about or beyond 10,000 years after site closure. Carbon-14 concentrations were well below the benchmark maximum concentration level of 2000 pCi/L at the 200 East and West Area LOAs. Concentration levels of uranium-238, the dominant uranium isotope, were also well below the benchmark maximum concentration level of 30 pCi/L at the 200 East and West Area LOAs at 10,000 years after site closure. Uranium-238 concentrations reached a peak of about 3 pCi/L at their peak (between 14,000 and 16,000 years after site closure) at the 200 West Area LOA.

Technetium-99 and iodine-129 concentrations were well below benchmark maximum concentration levels by the time they reached the Columbia River. Overall concentration levels from sources in the 200 East Area reached their peaks at the Columbia River LOA at about 260 years after assumed start of release. Contaminant levels from sources in the 200 West Area reached their peaks at the Columbia River LOA between 500 and 600 years after assumed start of release.

5.3.4.10.2 Wastes Disposed of after 1995

The highest water quality impacts from LLW and MLLW disposed of after 1995 resulted from releases of technetium-99 and iodine-129. Combined technetium-99 levels at the 200 East Area NW LOA were about 8 percent (77 pCi/L) of the benchmark maximum concentration level for the Hanford

Only waste volume. The primary source for these elevated levels was from inventories in MLLW disposed of after 1995.

- Combined technetium-99 levels were about 25 percent (225 pCi/L) of the benchmark maximum concentration level at the 200 West Area LOA. The source of these impacts was primarily from the technetium-99 inventory in Cat 3 LLW disposed of after 1995.

- Highest combined iodine-129 levels were about 37 percent (0.37 pCi/L) of the benchmark maximum concentration level at the 200 West Area LOA for the Hanford Only waste volume. The main contributor to these concentration levels was from inventories in MLLW disposed of after 1995.

Concentration levels of carbon-14 and the uranium isotopes at the 1-km (0.6-mi) LOAs down-gradient from source areas of LLW and MLLW disposed of after 1995 did not reach their peak values until after the 10,000-year period of analysis. Concentration levels for both constituents were well below the benchmark maximum concentration levels at 10,000 years after site closure.

Technetium-99 and iodine-129 concentrations were well below the benchmark maximum concentration level by the time they reached the Columbia River. Overall concentration levels at the Columbia River LOA from sources in the 200 East Area reached their peaks at about 850 years after site closure. Contaminant levels from sources in the 200 West Area reached their peaks along the river at between 1660 and 1820 years after site closure.

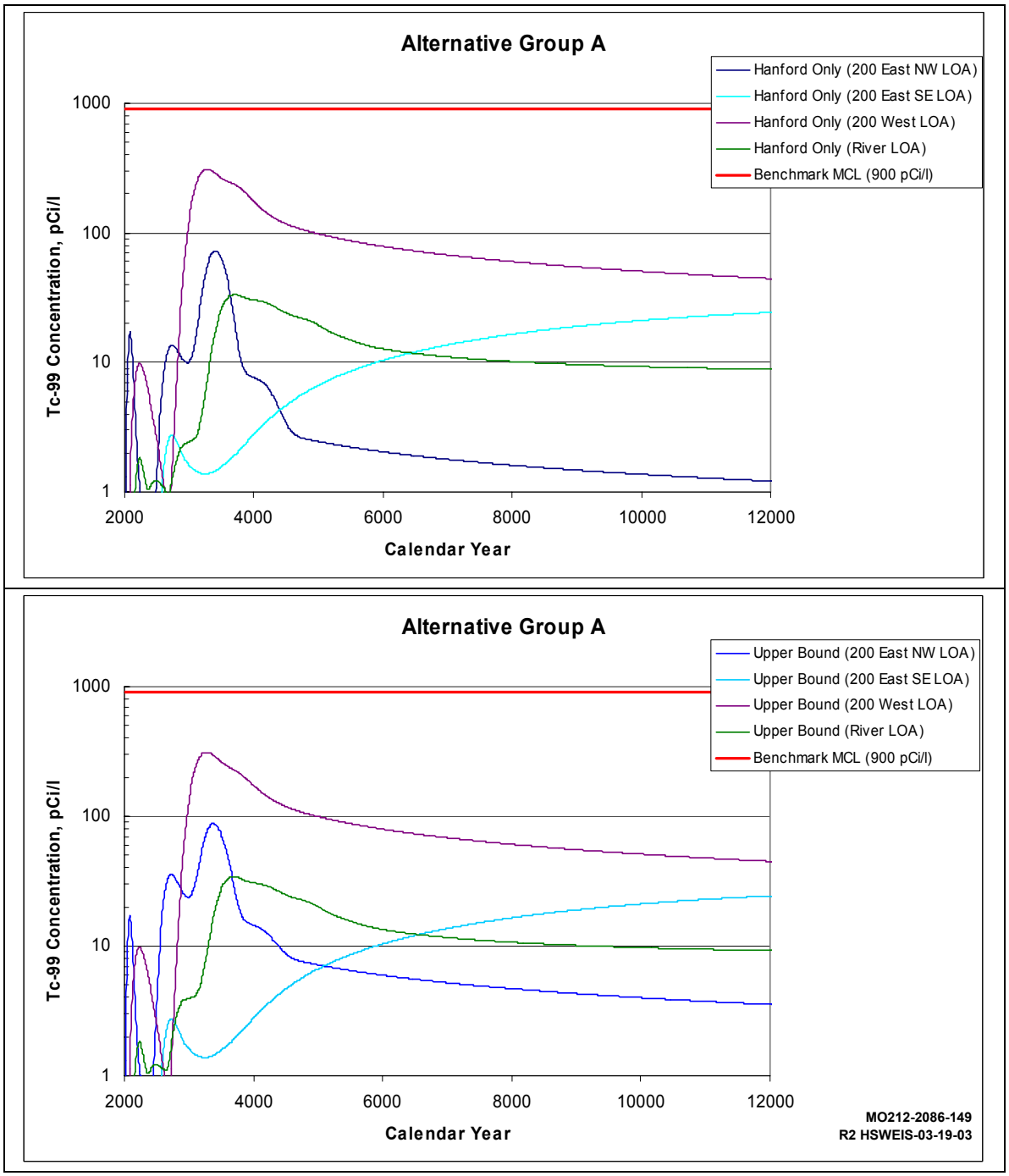

Figure 5.3. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group A

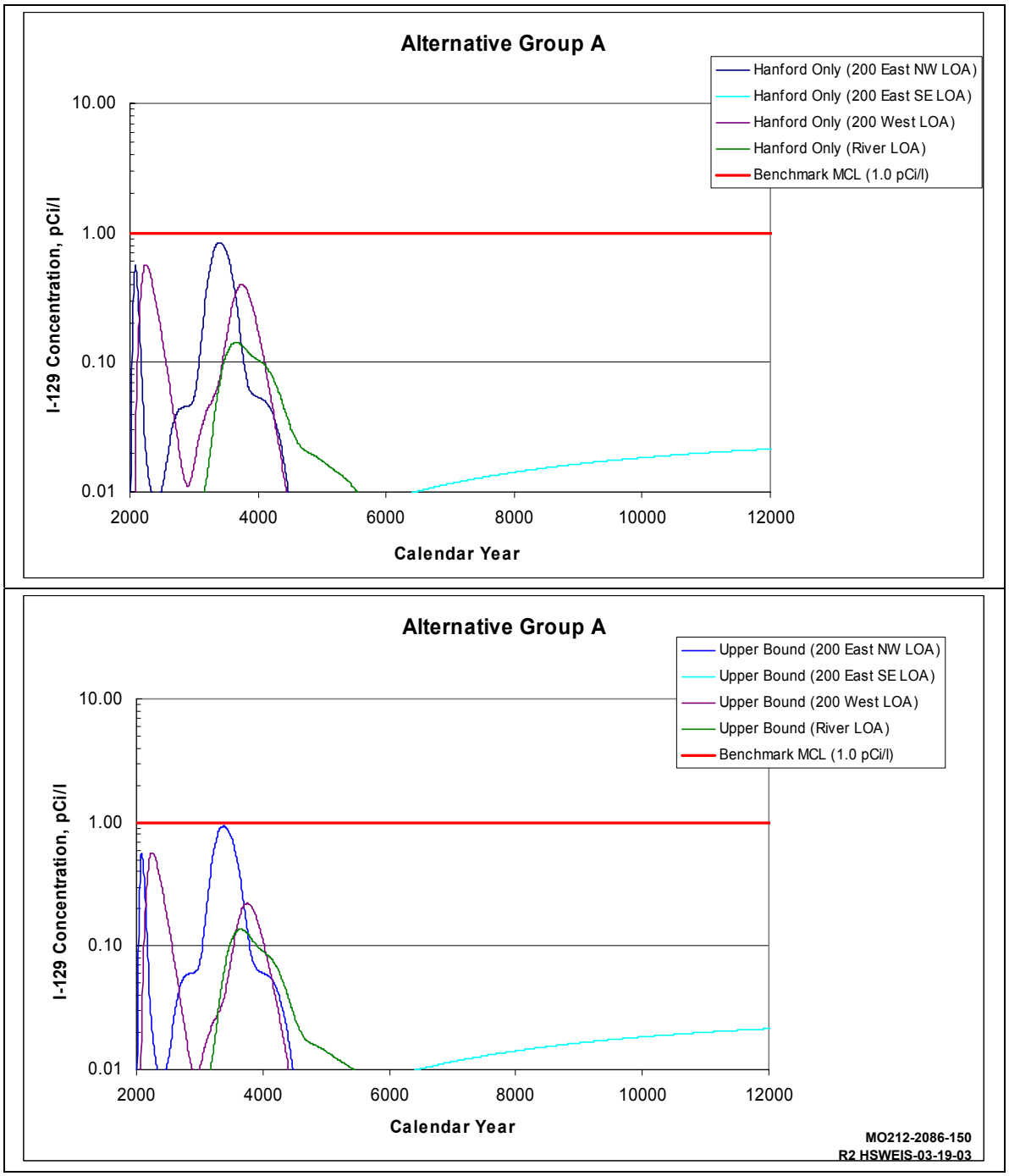

Figure 5.4. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group A

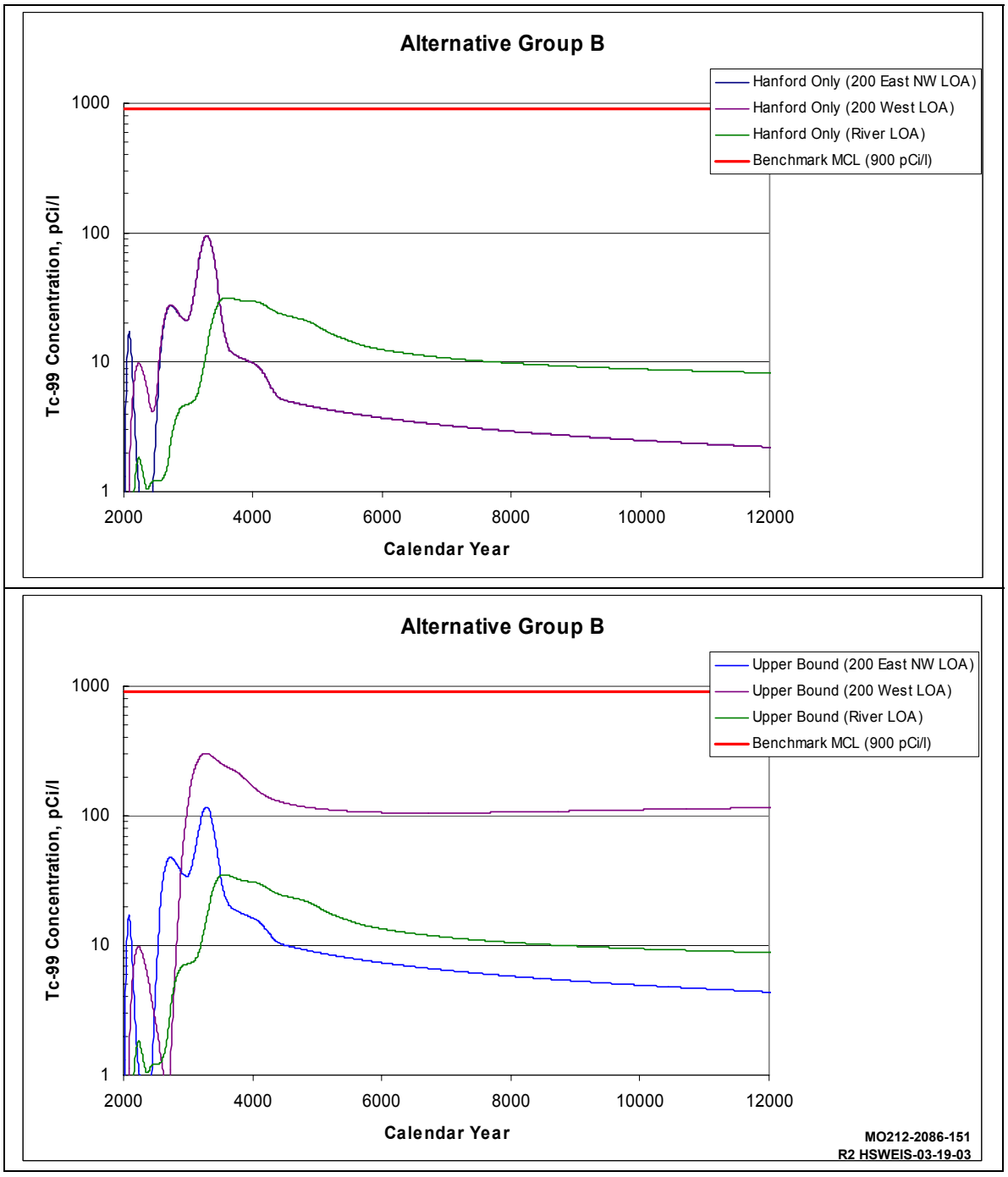

Figure 5.5. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group B

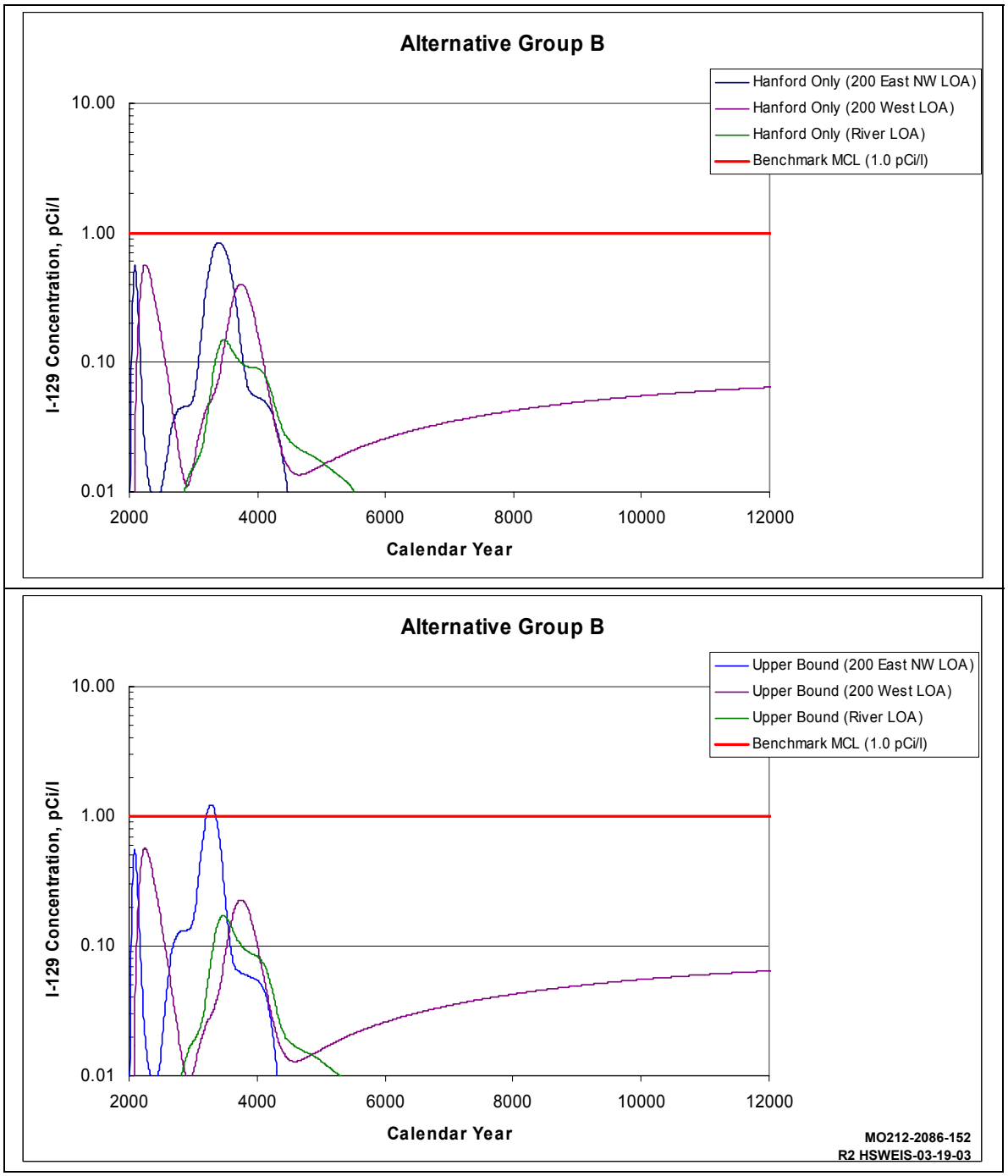

Figure 5.6. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group B

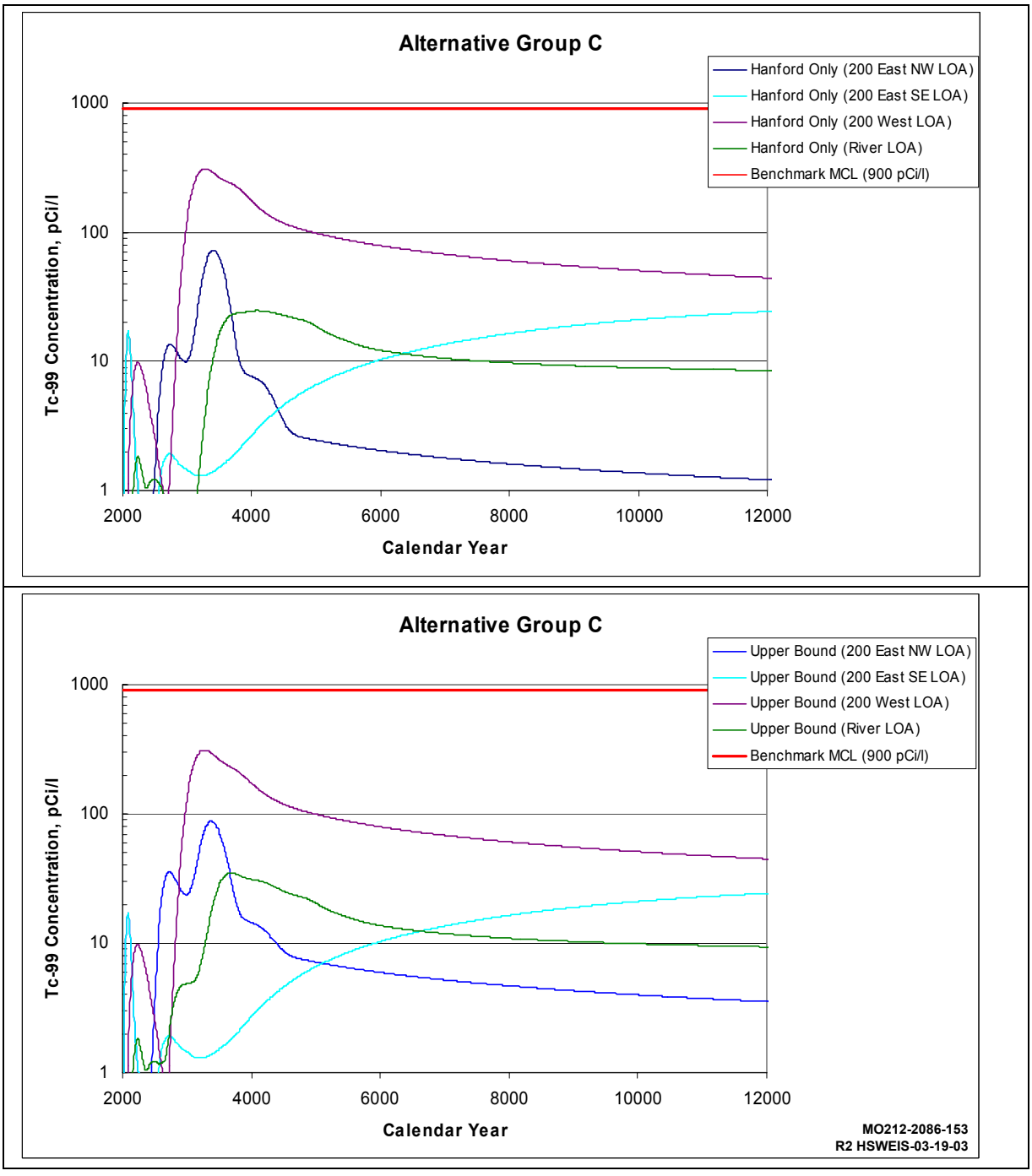

Figure 5.7. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group C

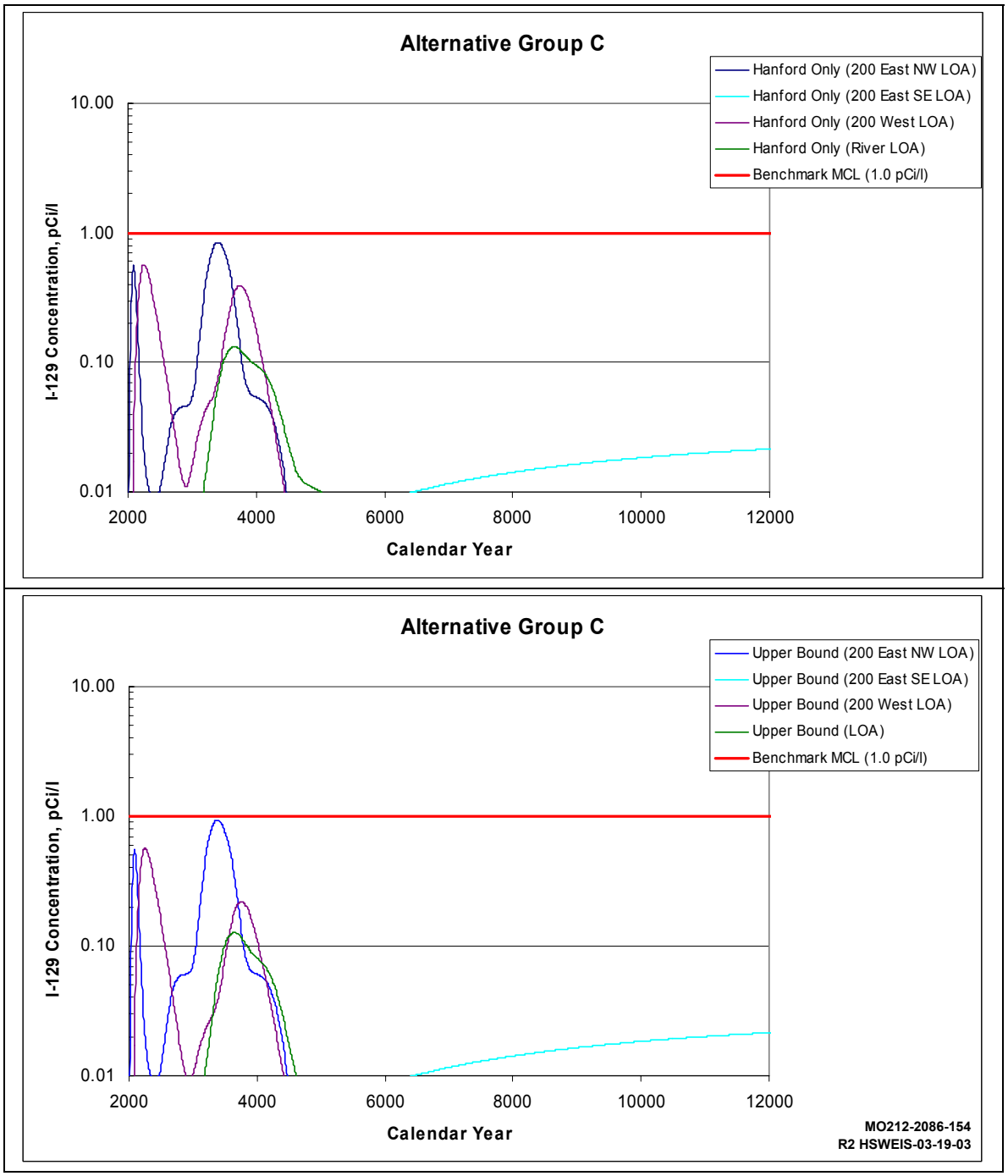

Figure 5.8. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group C

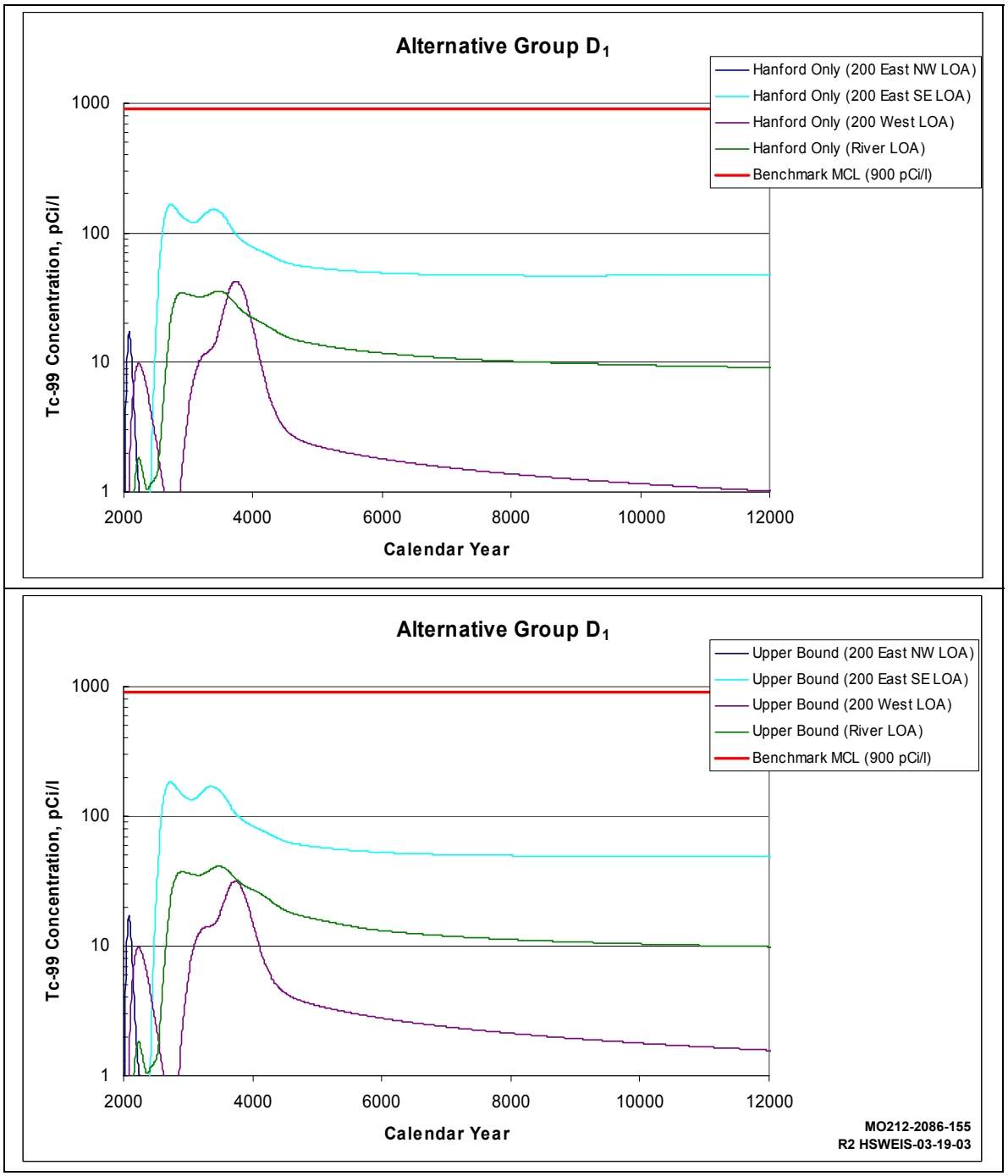

Figure 5.9. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group D_1

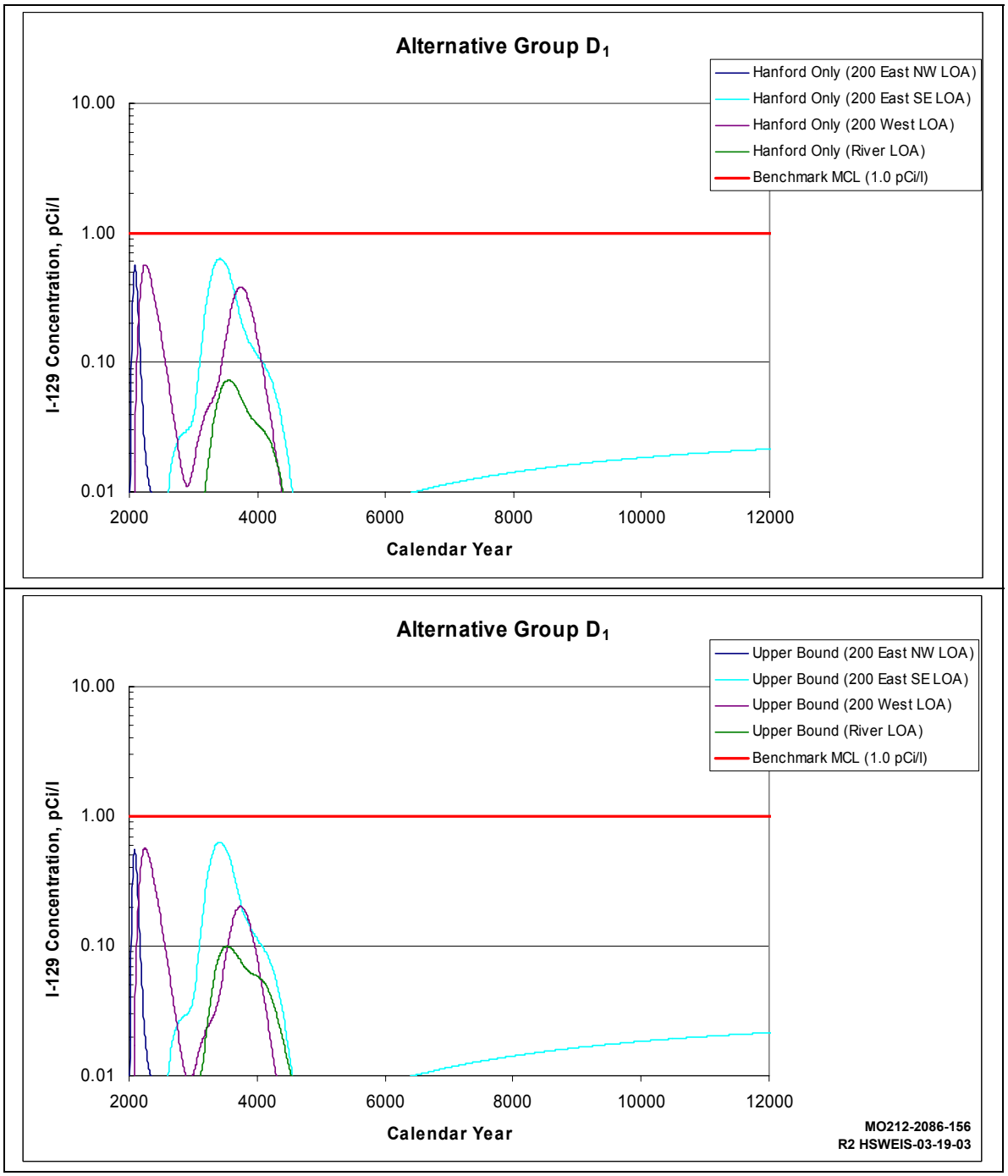

Figure 5.10. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group D_1

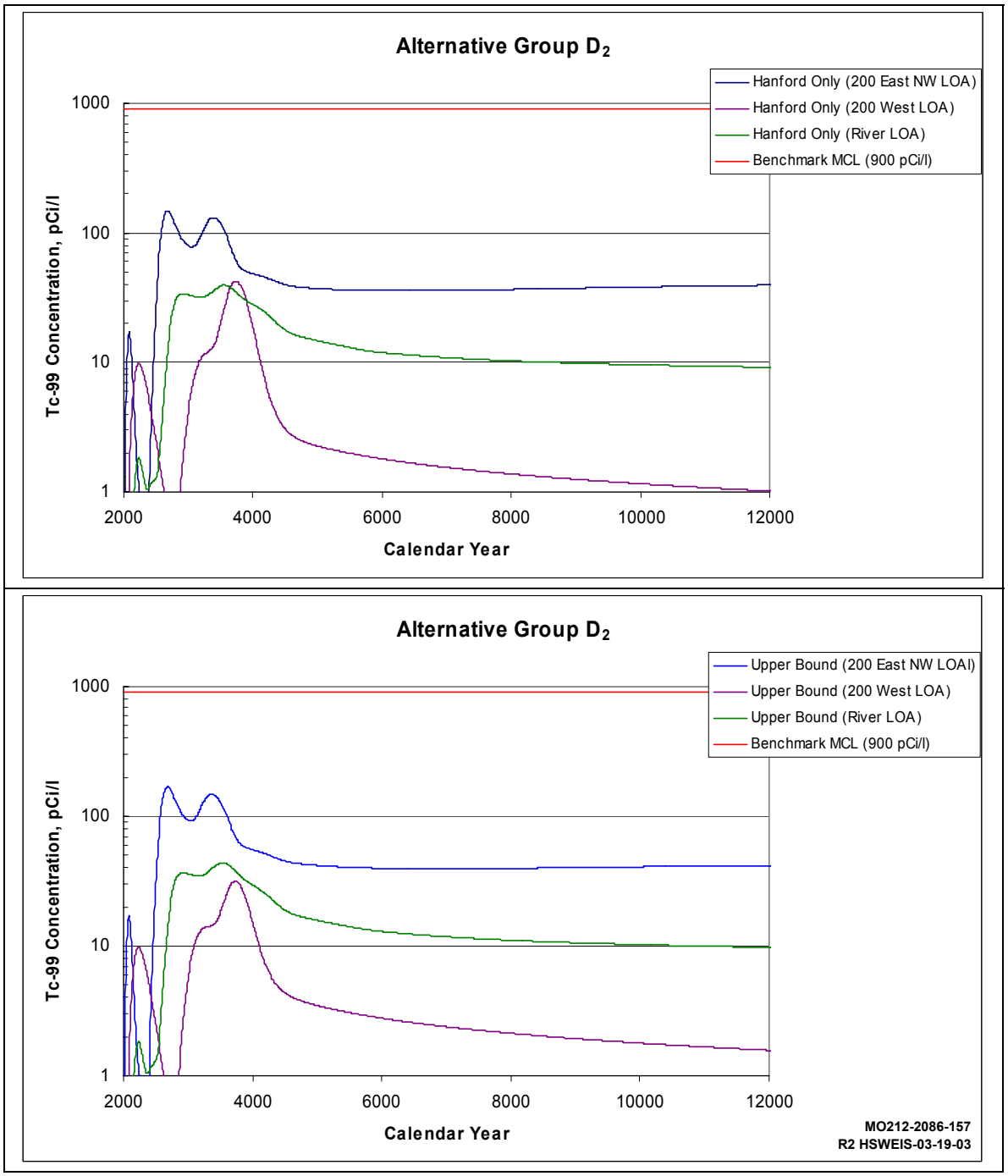

Figure 5.11. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group D_2

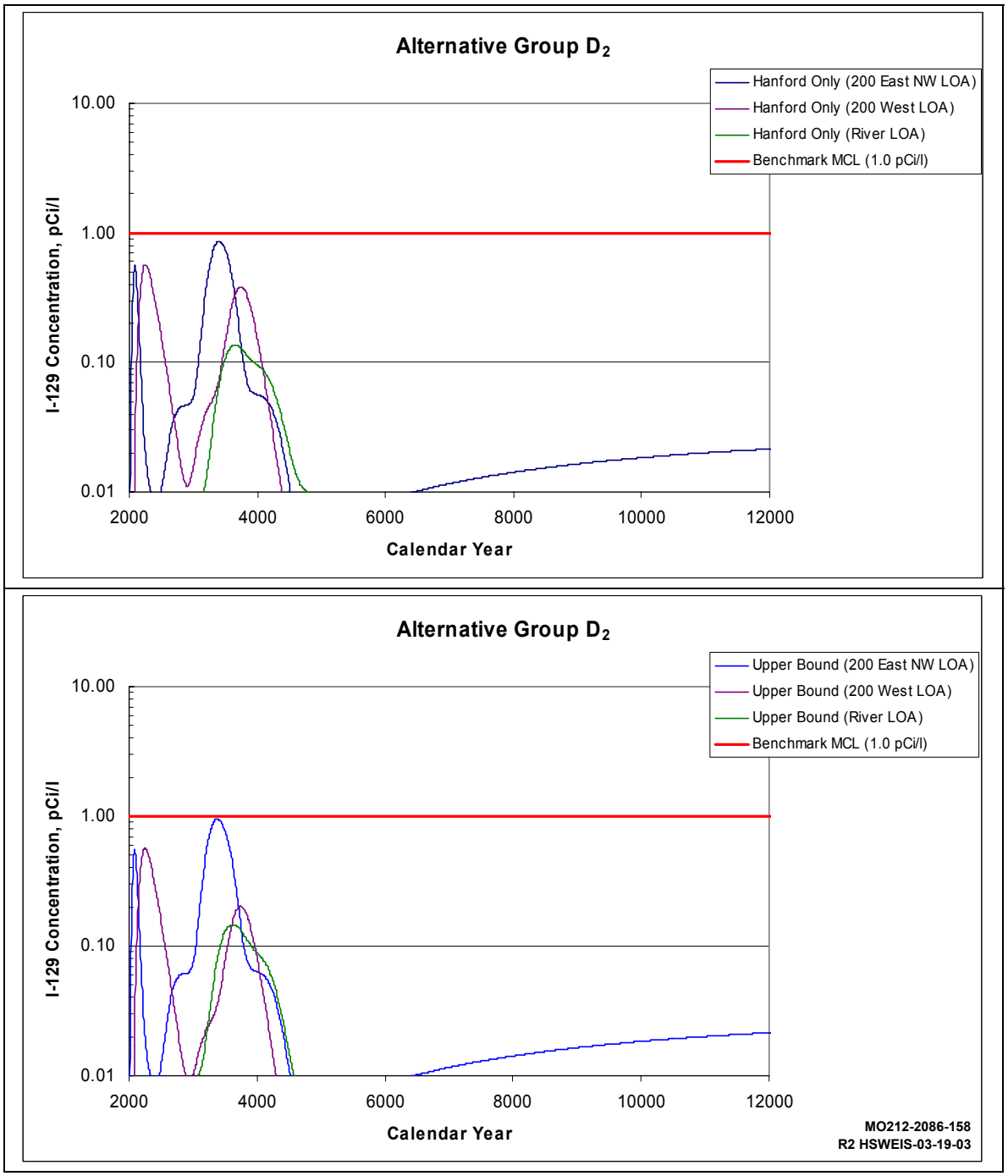

Figure 5.12. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group D_2

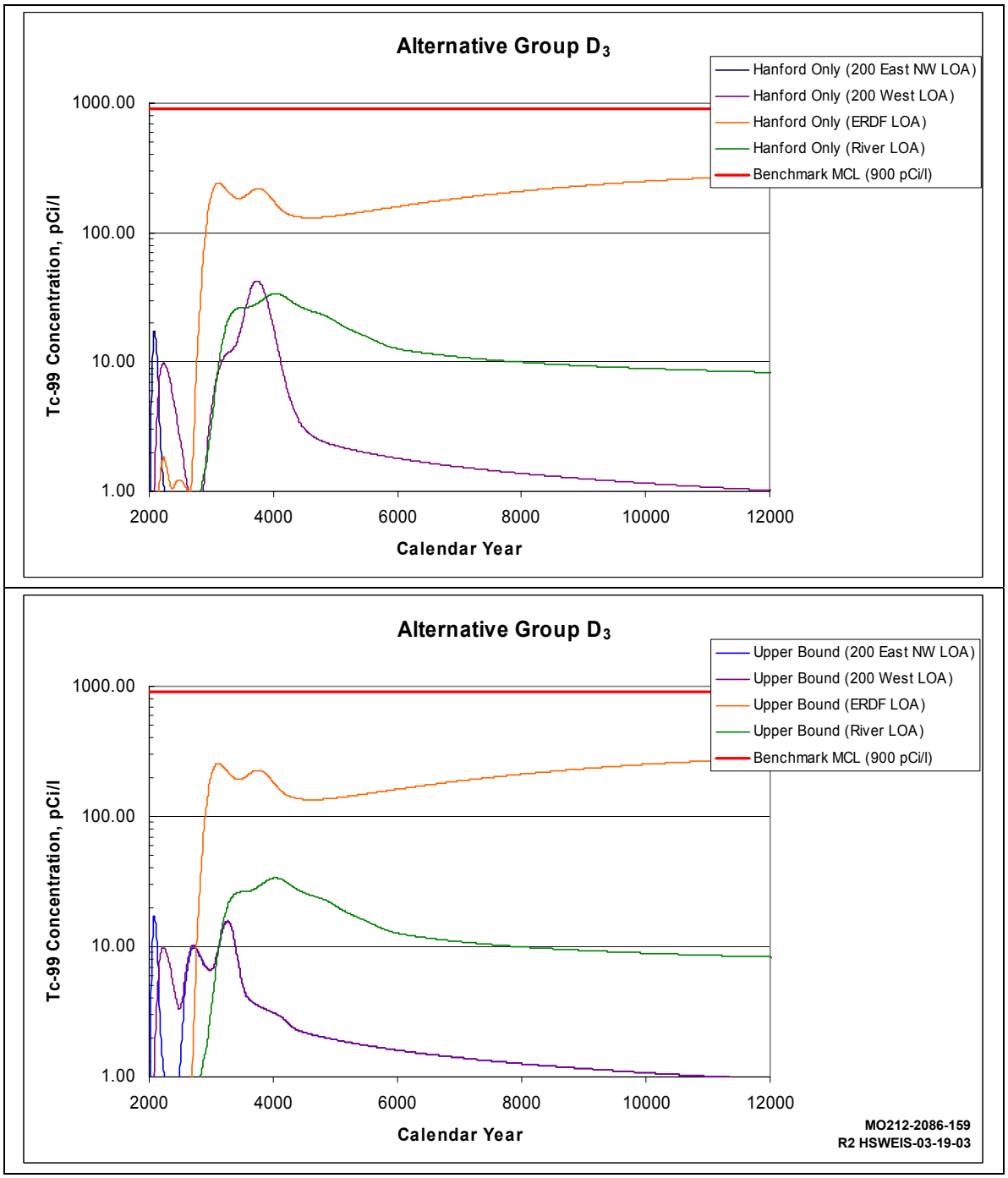

Figure 5.13. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group D_3

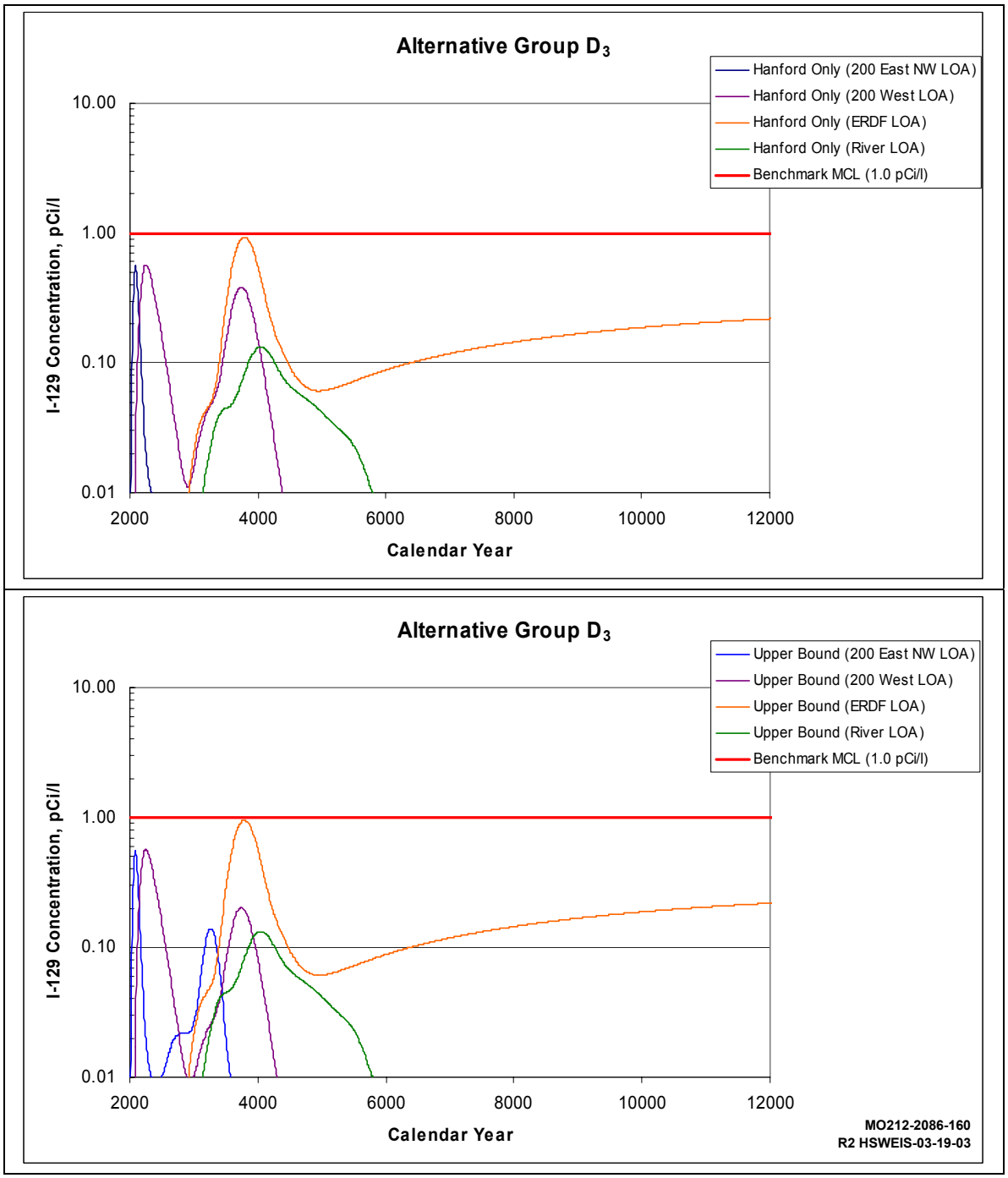

Figure 5.14. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group D_3

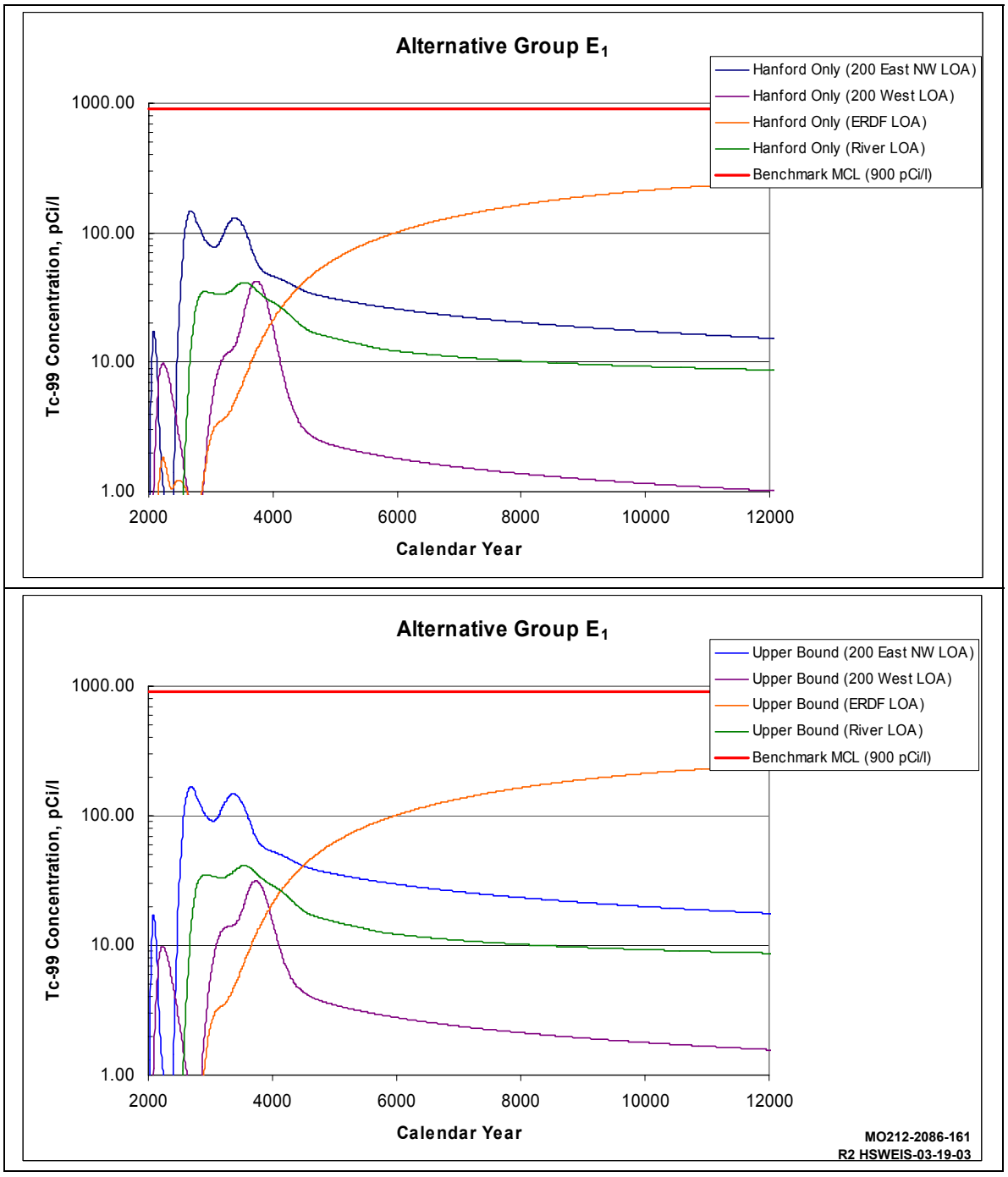

Figure 5.15. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group E_1

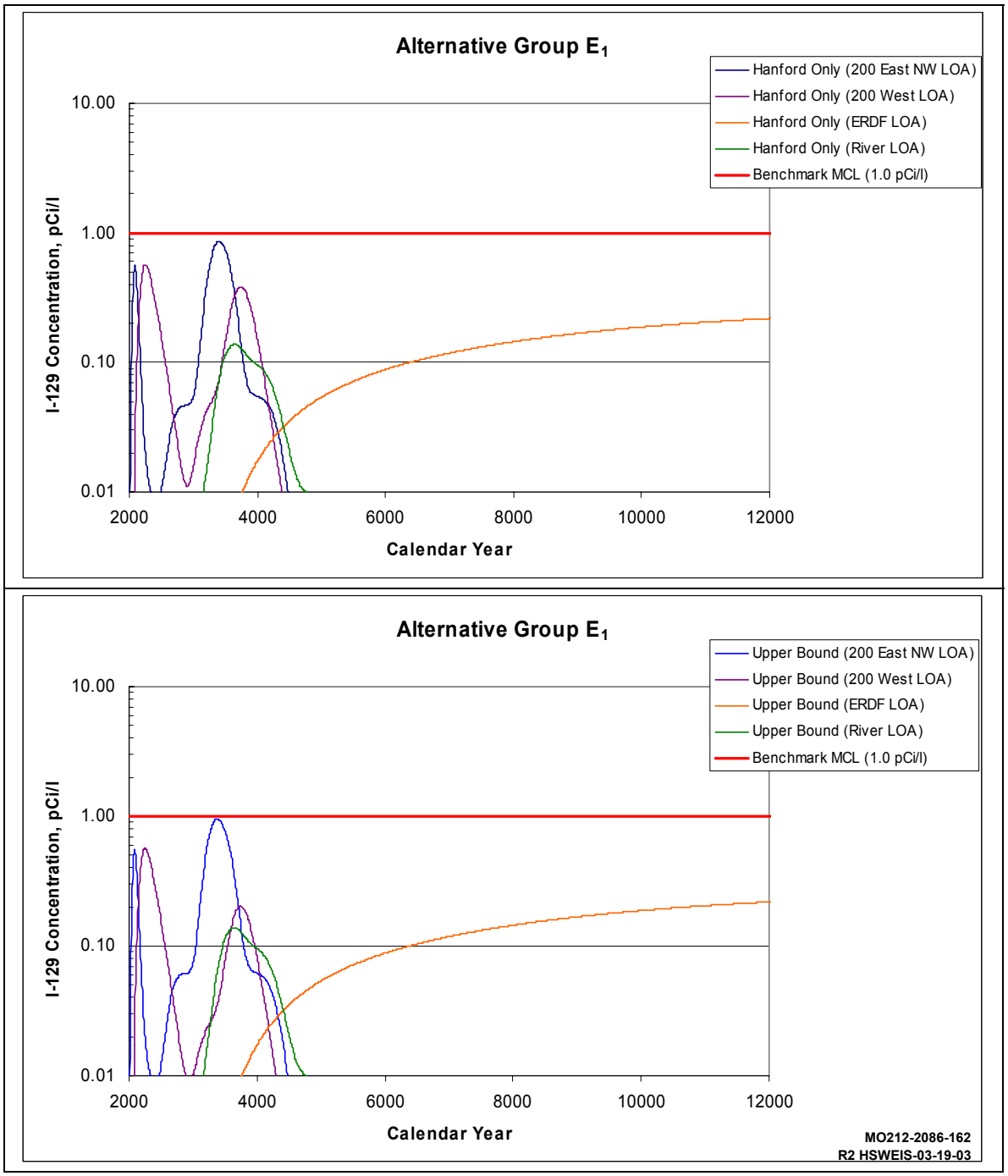

Figure 5.16. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group E_1

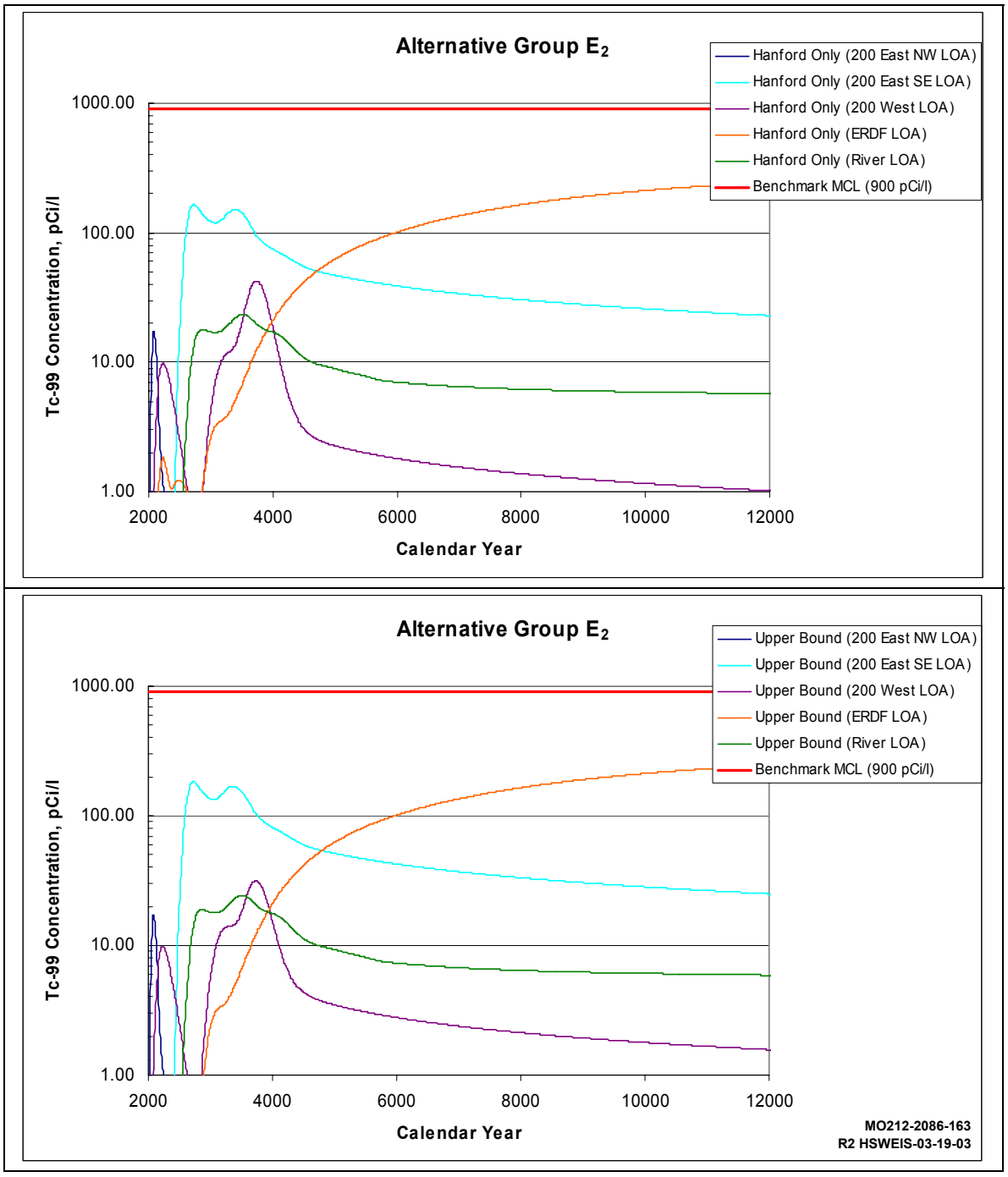

Figure 5.17. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group E_2

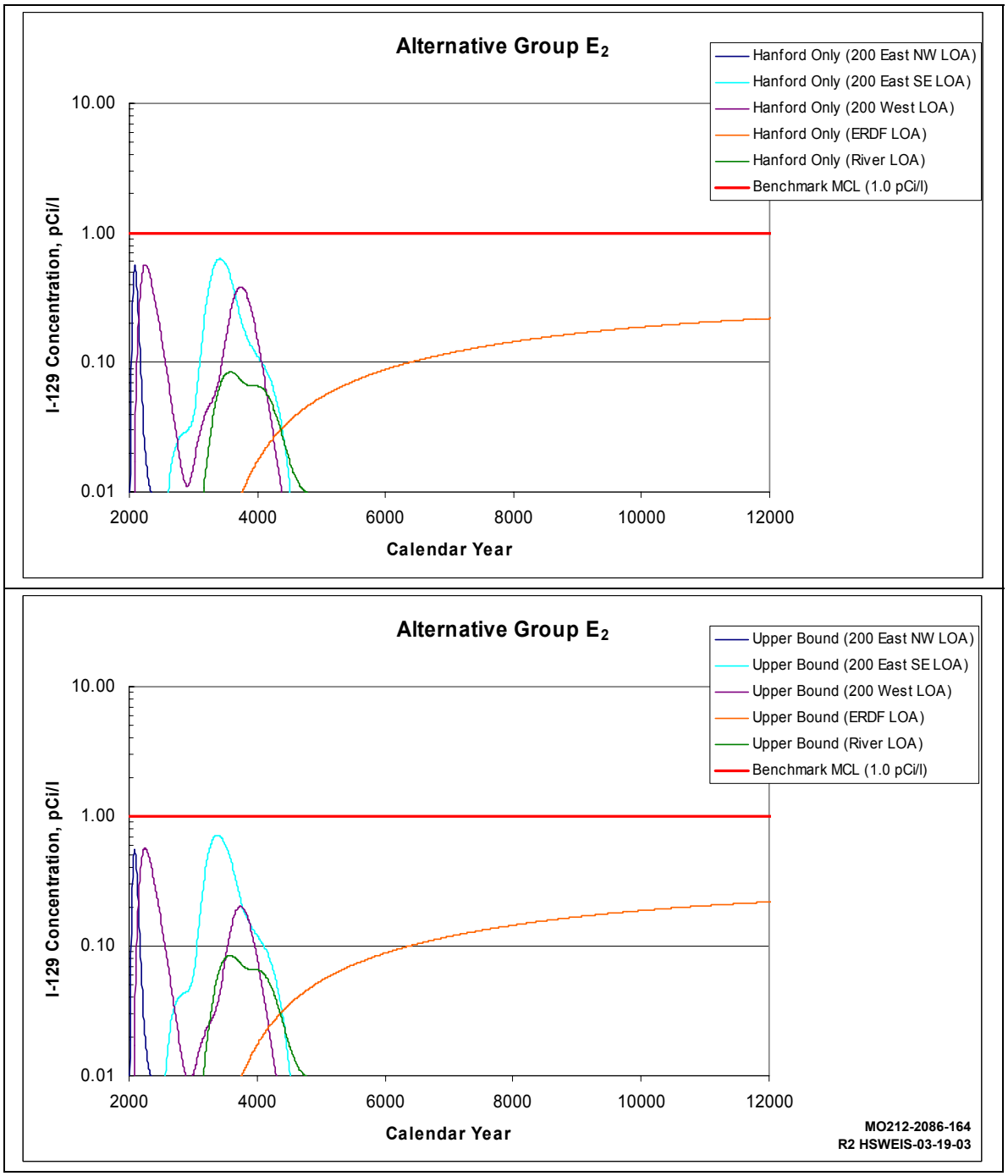

Figure 5.18. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group E_2

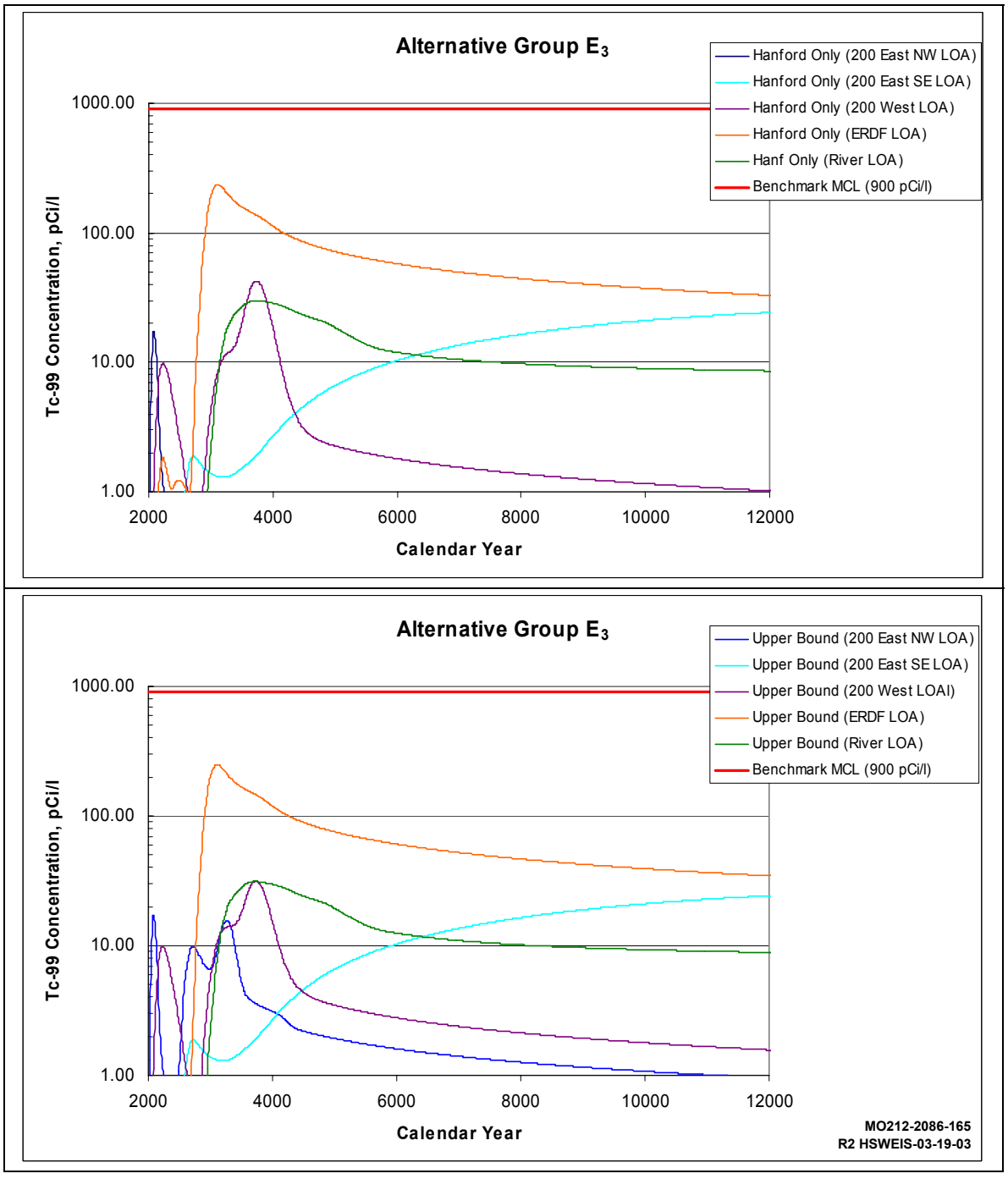

Figure 5.19. Technetium-99 Concentration Profiles at Various Lines of Analysis – Alternative Group E_3

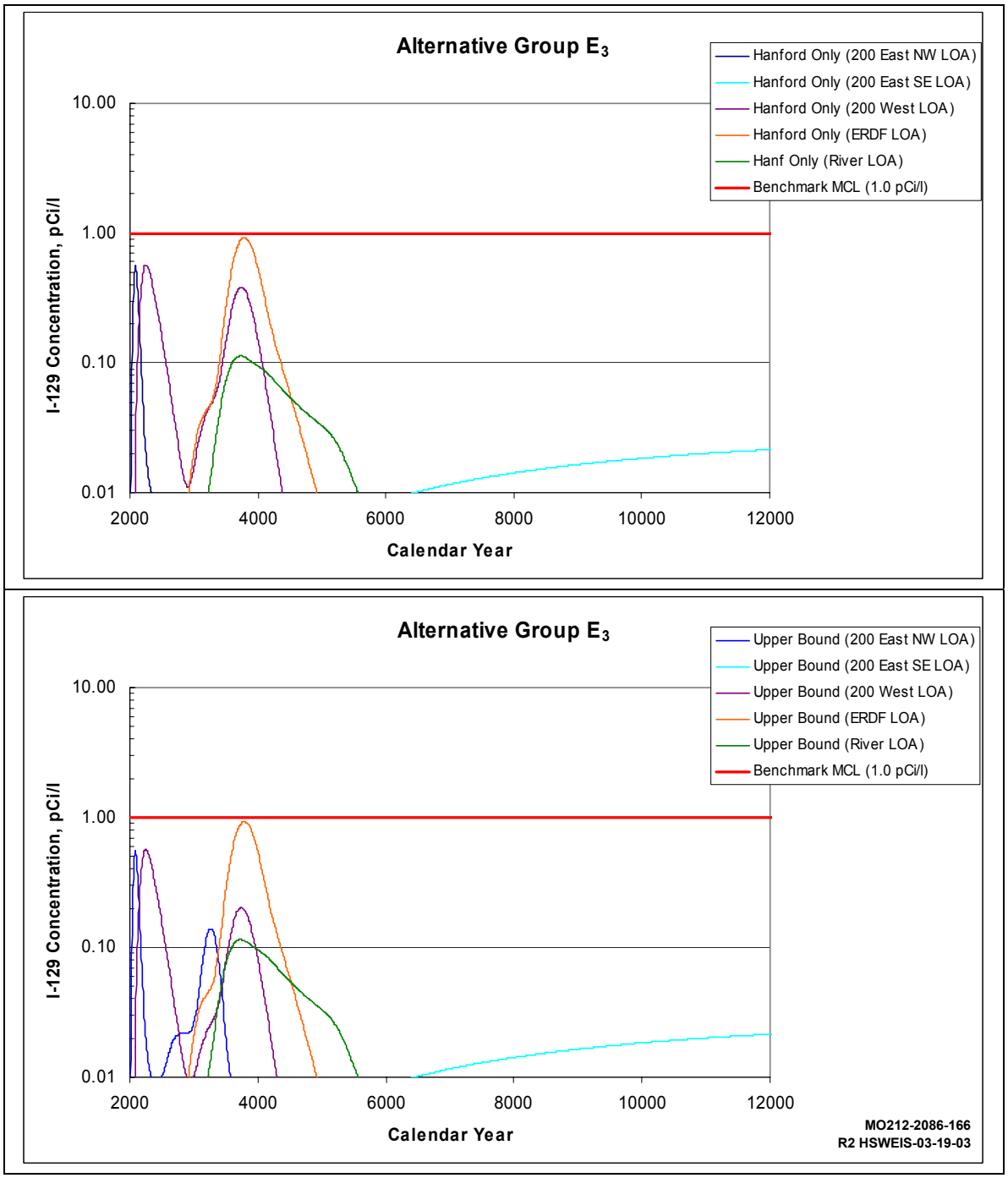

Figure 5.20. Iodine-129 Concentration Profiles at Various Lines of Analysis – Alternative Group E_3

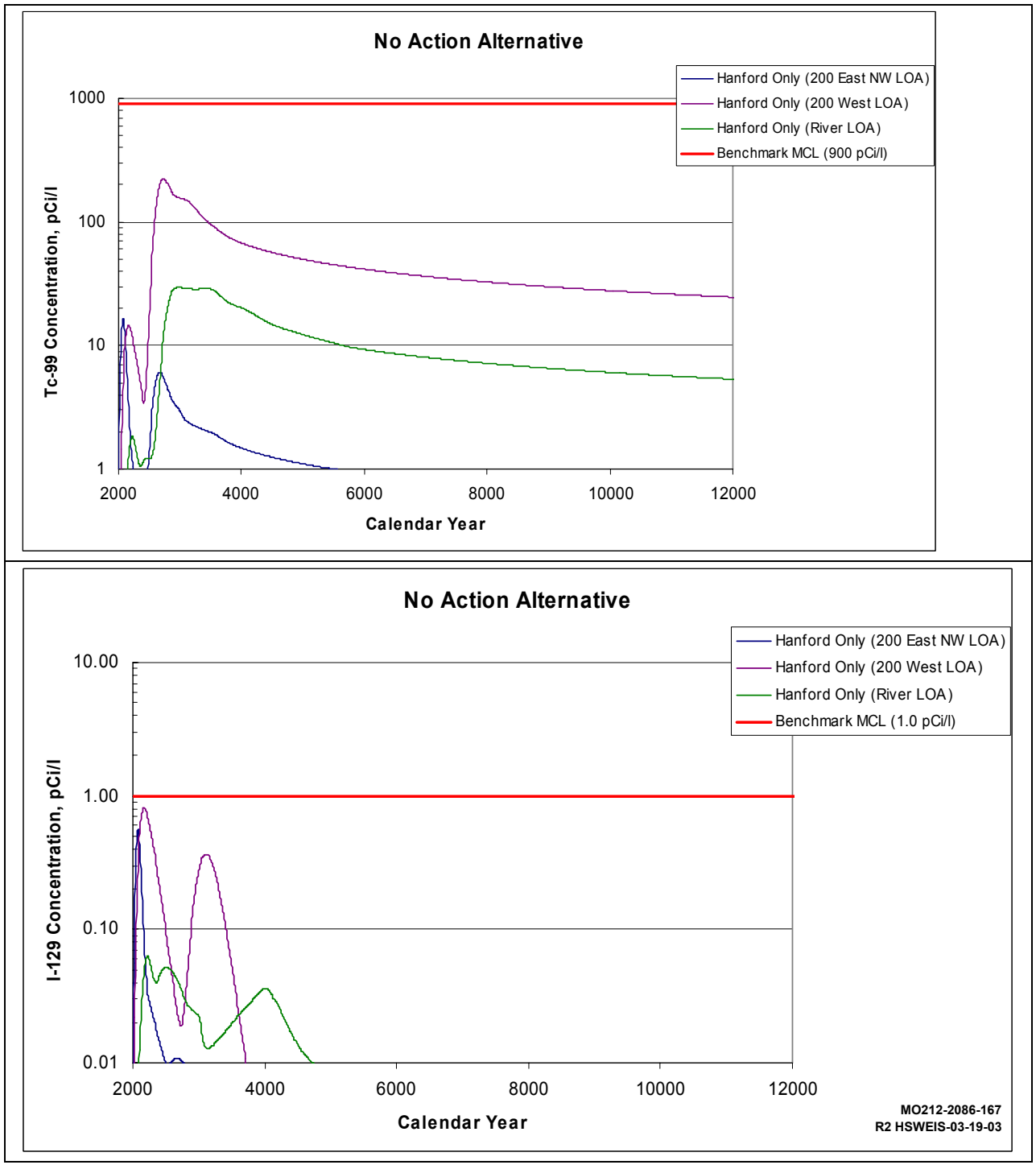

Figure 5.21. Technetium-99, and Iodine-129 Concentration Profiles at Various Lines of Analysis – No Action Alternative